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THE WILEY FARM SERIES

EDITED BY

A. K. GETMAN

SPECIALIST IN AGRICULTURAL EDUCATION, NEW YORK STATE DEPARTMENT OF EDUCATION

AND

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DIRECTOR OF EXTENSION, NEW YORK STATE COLLEGE OF AGRICULTURE

CORN AND CORN GROWING

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Specialist in Agricultural Education, New York State Department of Education

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CORN AND CORN GROWING

BY

HENRY A. WALLACE

AND

EARL N. BRESSMAN

THIRD EDITION

COMPLETELY REVISED

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PREFACE TO NEW EDITION

THE first two editions of Corn and Corn Growing have been exhausted. Many new things have developed and a complete rearrangement and revision has, therefore, been made under the supervision of A. K. Getman and C. E. Ladd. In making the revision the effort has been made to fit the needs of both high school and college students in agriculture. The figures in the Appendix have been brought up-to-date and new material has been incorporated. Attention is called to Chapter XXIV, which it is hoped can be used with good results in vocational agricultural schools. The blanks as given in this chapter should be a help in developing the problem method of teaching.

H. A. WALLACE
E. N. BRESSMAN

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CORN AND CORN GROWING

CHAPTER I

PICKING AND STORING SEED CORN

PICKING SEED CORN

THE safest time to pick seed corn is in late September or early October. Early picking is especially worth while in such years as 1915, 1917 and 1924, when the months of June, July and August are unusually cool and rainy. Corn which contains more than 30 per cent moisture is quite easily damaged by ordinary freezing weather, such as oftentimes occurs in late October and early November.

The method to use.—The amount of seed to be picked, cost of equipment and climatic conditions will determine the method of picking seed corn that is best for any particular situation.

Most farmers who pick their seed corn in early October go through the field with a sack over their shoulder. This is a very good but somewhat tiresome method. A more convenient method employed by some farmers is to drive through with a regular wagon fitted up with bang-boards as for ordinary husking. Six or seven rows are husked instead of two, but only the best 20 to 30 per cent of the ears are thrown into the wagon. When the end of the field is reached, the team can be turned to come back on the same down row, with the result that seed is thrown into the wagon from a total width of twelve to fourteen rows for each down row. A single day in the field with this

kind of an outfit will give the average farmer all the seed he needs for the following year.

The kind of ears to pick.—The man who picks seed corn in the field does not have any time to examine in great detail the characteristics of each ear. He can, however, pick ears that are carried on stiff stalks about four feet from the ground, ears which are medium large, well matured, and solid. No ear should be saved which is moldy or which comes from a stalk infested with smut, rot, or any other kind of disease. In Illinois, Iowa and Nebraska, it seems to be decidedly worth while to pick for ears with a rather smooth dent, ears with kernels which are smooth, shiny and horny. At the Nebraska station, after six years of experimenting, it was found that the ears with rather shallow, smooth and flinty grains yielded from four to five bushels per acre more than ears with deep, rough and somewhat starchy grains.

FIG. 1.—Picking seed corn. He sees a solid ear, well matured on a healthy stalk.

Experiments at many different stations have proved that it does not pay to pick the seed ears for any pronounced type. At the Ohio station, for instance, after ten years' work it was found that the seed ears 6 or 7 inches long yielded within a bushel or two per acre as much as the seed ears 9 or 10 inches long. Seed ears which were tapering yielded a bushel or two

more per acre than those which were cylindrical. Ears with an inch of bare tip showing yielded almost exactly the same as those with the tips completely filled. The smooth ears yielded about two bushels per acre more than the rough ears, the difference in favor of the smooth ears not being nearly so pronounced as in Nebraska.

Iowa experiments indicate that ears with broad, thick kernels yield on the average four or five bushels more per acre than ears with narrow, thin kernels of a shoe-peg type. Apparently, about all that can be done so far as type of ear is concerned, when picking seed corn in the fall, is to select solid, well-matured ears with rather broad, thick kernels. During the winter it may be possible to go over the ears more carefully after they are hung up, but in the field it is impracticable to spend more than a second or so on any individual ear.

The importance of early picking.—Corn, when it first becomes well dented and hard glazed, contains about 40 per cent moisture. In the ordinary year, in the central part of the corn belt, the best matured ears reach this stage about the middle of September. In cold, backward seasons like 1915, 1917 and 1924, however, only a few of the ears will be well dented, hard and down to 40 per cent moisture by October 1. A well-dented ear of this sort will stand the ordinary light frost without damage. If, however, the temperature goes below 20° for more than eight or ten hours, very serious damage is likely to be done, even to the more mature corn.

Table I, taken from Bulletin 188 of the Nebraska experiment station, illustrates why it is so important to protect seed corn from freezing until its moisture has been reduced to less than 15 per cent.

In many seasons, when the weather is rather hot and dry during August and September, the best matured ears will contain less than 20 per cent moisture on October 1, and there is not much chance of serious damage to the corn for seed even though it is left out until Christmas time. In most years, however, even the best matured seed ears contain around 20 per

cent moisture in the middle of October and are therefore likely to be damaged if the temperature goes below 15°.

TABLE I

Relative Germination of Corn of Varying Moisture Content

Per Cent

Moisture content of grain (per cent)	10 to 15	15 to 20	20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	50 to 55	55 to 60	60 to 65
Temperature ranges in degrees F.											
32 to 28	100	100	100	85	75	71	69	*	33	31	0
24 to 20	100	100	96	77	67	13	12	12	6	0	0
16 to 12	100	100	88	34	12	0	0	0	0	0	0
8 to 4	100	98	47	7	0	0	0	*	0	*	*
0 to −5	97	63	0	0	0	0	0	0	0	0	0

* No tests run with corn of this moisture content at this temperature.

Miscellaneous Methods Used

It is still possible oftentimes to get good home-grown seed corn even though it is not picked out of the field in early October. In the average year it is possible to get good seed corn at husking time, and many farmers therefore put a box on the side of their wagon in which they place the best looking seed ears. Other farmers pick their seed ears out of the husked corn as it is being shoveled or elevated into the crib. Others wait until spring and pick their seed corn out of the crib. About half the time, according to experiments conducted at the Ohio station, crib corn germinates and yields very satisfactorily, but the other half of the time the yield is likely to be very seriously reduced because of low germination. Crib corn, if it is given a very careful ear by ear test, is quite satisfactory, but the labor of giving an ear by ear test is greater than picking the seed corn

in early October and storing it where it will not be damaged by freezing weather. Moreover, the yielding power of ear-tested crib corn is not quite so good on the average as corn which is picked early and properly hung.

STORING SEED CORN

Seed corn when brought in from the field in early October ordinarily contains from 30 to 40 per cent moisture, and the

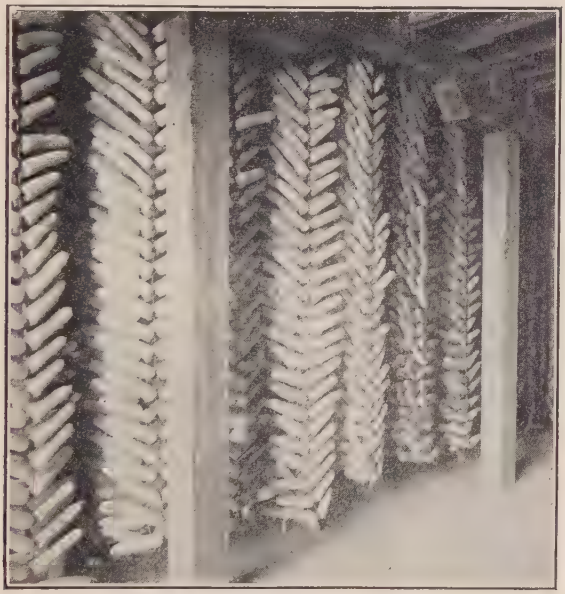


FIG. 2.—A full seed corn house.

object in storing is to reduce this moisture content as rapidly as possible so that there will be no likelihood of freezing injury. The ears should be properly stored in a dry, well-ventilated place where there is little danger of freezing until the kernels have been reduced to less than 15 per cent moisture.

The place to store seed corn.—There are many places on the farm where seed corn is stored. Some of these places are

satisfactory and others are objectionable. A heated room in the house appears to be best if a special seed corn building is not available. Growers who are making a business of producing seed corn should have a well-built house just for seed corn. This house should not only have all of the requirements of seed protection such as ventilation, dryness and heat, but also should be convenient for storing, testing, shelling, grading and shipping the product.

TABLE II

YIELDING POWER OF SEED CORN STORED IN DIFFERENT WAYS.
(OHIO STATION)

Germination, Per Cent

Methods of Storage	1913	1914	1915	1916	1917	Five-Year Aver.
Lot 1—In rack over crib	97.50	94.33	97.83	92.33	99.50	96.30
Lot 2—In pile on floor over crib	92.00	89.00	97.00	92.17	98.33	93.70
Lot 3—In crib	88.17	92.67	95.33	72.33	98.50	89.40
Lot 4—In rack in warm room	96.67	95.50	98.83	95.83	99.17	97.20
Lot 5—In furnace room, hung up	98.67	94.33	97.33	98.33	99.00	97.53
Lot 6—In bin of oats	87.17	94.83	98.83	85.00	98.33	92.83

Yield of Corn Per Acre, Bushels

Lot 1—In rack over crib	81.54	59.21	55.97	60.10	106.06	72.58
Lot 2—In pile on floor over crib	79.07	58.86	54.85	61.12	106.53	72.09
Lot 3—In crib	74.25	62.86	59.86	50.00	108.14	71.02
Lot 4—In rack in warm room	78.64	65.29	59.64	60.02	103.89	73.50
Lot 5—In furnace room, hung up	77.89	68.07	62.59	59.87	106.89	75.06
Lot 6—In bin of oats	72.32	66.57	55.88	53.75	107.50	71.20

At the Ohio station, as an average of five years, it was found that corn hung up in the furnace room yielded best, whereas crib corn and corn stored in the oat bin yielded poorest. In

this Ohio experiment the corn was all picked in the field at the same time, and so it is safe to say that the difference in germinating power and yield are due to the method of storage and not to any difference in time of picking. It will be noted that in one year the crib corn yielded more than the corn stored in any of the other ways, but that as an average of the five years the corn hung up in the furnace room yielded an average of several bushels more per acre.

If seed corn kept in a heated room will yield several bushels per acre better than corn hung over a crib, it may be worth while for farmers to fix up a place in their furnace room or attic or in a spare room for seed corn. Of course, a damp cellar or a closed attic where there is poor ventilation of air should be avoided. The two objects are to dry out the corn and to protect it from freezing until it is thoroughly dry.

FIG. 3.—The twine hanger.

In 1918, following the cold, backward season of 1917, germination tests were run by the Ohio station in the same way as during the five-year period, 1913-17. The crib corn (Lots 1, 2 and 3) germinated less than 9 per cent. The corn in the bin of oats germinated 86 per cent, and the corn in the warm room and furnace room germinated better than 93 per cent. No yield test was run in 1918. Apparently, heat dried corn has only a slight advantage in the ordinary year, but following a

backward season like 1917 the corn which is not artificially dried is likely to be a complete failure.

Method of Hanging Seed Corn.—Many methods have been devised for hanging seed corn so that there will be a free circulation of air around the ears to carry off the moisture as rapidly as possible. A number of seed corn racks are on the market which are very convenient. However, one of the cheapest, most convenient and most satisfactory hangers for storing seed corn can be made out of electric-welded hog-tight fencing. The electric-welded fence wire has a 2 x 4 rectangular mesh and the hangers are cut from it the long way. Every other wire is cut in such a way that 4-inch prongs are left for a pair of ears each 4 inches. The wire may be cut with a cold chisel and a hammer, using a piece of iron on which to rest the wire as shown in picture on next page, or a pair of sharp lineman's cutting pliers may be used.

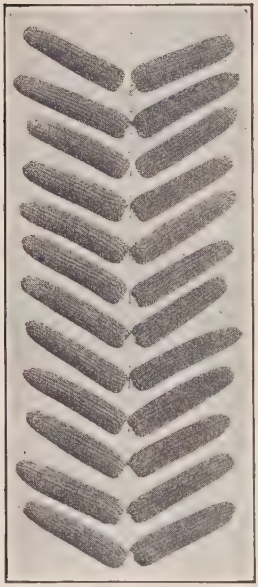


FIG. 4.—Hanging seed corn on electric welded fence wire.

Ordinarily it is best to cut these hangers so that each hanger will accommodate from ten to fifteen pairs of ears. By using a pair of pliers, the end of the main rib of a hanger can be bent so that several of them may be attached one to the other.

Farmers who have used this type of seed corn hanger with several hundred bushels have found it thoroughly satisfactory and cheaper than any other hanger they can buy. The cost of the labor and material for preparing the hangers for a thousand ears need not exceed two dollars. After the corn is taken from the hangers in the spring, they can be wired together conveniently and stored away in a small space.

Some people make hangers by driving nails into boards, poles or posts. Others make lath racks by tacking laths 4 inches apart on each side of 4-inch uprights. There are scores of such devices, all of which are good.

Drying with artificial heat.—Seedsmen specializing in seed corn have worked out several different devices for forcing heated air through the corn in a bin. The corn is picked in early October and thrown into the bin, and the heated air is

FIG. 5.—Making seed corn hangers out of electric welded fence. Note the alternate wire method of cutting.

immediately forced through it, the object being to reduce the moisture content of the corn from above 30 per cent to less than 10 per cent within three or four days. The standard method is to have a bin about 8 feet each way with tight sides and a slatted bottom with an air chute below the slatted bottom. A furnace and blower or fan are used to force the hot air through the corn. It seems to be essential, if the germinating power of the corn is not to be damaged, that the temperature of the air should not be above 120°. On the other hand, it should not be

below 100° if the moisture is to be carried off most economically. It seems that a plan of this sort is not practicable except where more than 500 bushels of seed corn is being handled each year.

Fuel and power to dry a bushel of corn in early October costs about 15 cents. Ordinarily the drying is completed in three or four days when the air is forced through the corn at a temperature of 110°. Germination tests have proved that corn dried in this way contains less mold than the same kind of corn dried on hangers in the ordinary farm manner. One of the authors of this book has used this method for several years with excellent results.

CHAPTER II

HARVESTING CORN

THE six general methods of harvesting are:

1. Husking the ears by hand from standing stalks.
2. Snapping the ears by hand from standing stalks.
3. Husking the ears by machine from standing stalks.
4. Cutting the stalks for silage.
5. Cutting the stalks for fodder.
6. Harvesting with live stock.

The fourth and fifth of the methods listed above are discussed in a later chapter.

DETERMINING THE METHOD OF HARVEST

The use that the grower wishes to make of the crop is the most important factor in determining the method of harvest. Other factors such as climatic conditions, labor available and storage conditions are often important considerations.

Husking by hand.—Most of the crop in the Corn Belt is husked by hand from the standing stalks after heavy frost. At this time the ears are dry enough to crib and they break from the stalks more easily. Before corn is picked, the husks should be dry and the kernels hard. Ordinarily, harvest begins the latter part of October and is completed at Thanksgiving time, but fields occasionally stand throughout the entire winter.

The two methods of husking by hand from standing stalks are peg husking and hook husking. The pioneers used a husking peg or pin, somewhat similar to that illustrated here, but usually made it either out of hickory wood or bone. Peg husk-

ing was universal until the late nineties, when hook husking began slowly to displace it, especially among the younger generation. To-day most of the corn of Iowa, Illinois and Nebraska is husked with a hook. The first hook was invented by W. F. Lillie of Gage county, Nebraska, in 1892, in order to make it possible for an uncle who had lost a thumb to husk corn. An altogether different motion was required with the hook than with the peg, and the new invention did not begin to make much progress until 1896.

Fig. 6.—Corn husking champion Fred Stanek at work.

To-day the average peg husker husks about 70 bushels in a ten-hour day and the average hook husker about 85 bushels. Practically all of the really fast corn husking has been done with the hook. Young men who have developed special skill in husking with the hook have, with all conditions favorable, husked 250 bushels in ten hours' field husking time. Under contest conditions, it has been proved that with all conditions favorable it is possible to husk 35 bushels in an hour. A champion husker husking this fast will leave about one ear in fifty behind and will leave about 7 or 8 ounces of husks on 100 pounds of ears.

The condition of the corn has a lot to do with the speed of husking. When the corn weighs 70 pounds per 100 ears, the records will be about 30 per cent faster than when it weighs 50 pounds per 100 ears. And, of course, much better records can be made if the corn is standing up well with the husks hanging loose. The smaller-eared, more thickly planted, heavier-husked corn of northern Iowa is much harder to husk fast than

the typical Reid corn of southern Iowa. Reid corn has a smaller shank and thinner husk than such varieties as Leaming and Silver King.

In the typical hook husking method, in the case of the ordinary ear hanging point downward, the motions are: First, the left hand grasps the ear about the middle with the thumb down or toward the point of the ear, and the tip of the ear is elevated a few inches. Almost simultaneously the right hand with the hook on it is swept across the husks on the under side of the ear, cutting them and making it possible for the fingers of the right hand to grasp the ear free of husks. The

FIG. 7.—*Left*, old-fashioned husking peg. *Right*, modern husking hook.

left hand on the upper side of the ear holds the husks back on that side, and the right hand jerks the ear loose and swings it into the wagon with a single motion. It all sounds quite complicated, but the various motions are done so nearly at the same time that good huskers can husk forty ears a minute and keep it up. It is possible for short periods of time to husk more than fifty ears a minute.

In the case of peg husking, there are three distinct motions which do not blend into each other quite so smoothly as in hook husking. Peg husking is cleaner than hook husking, however, and the average peg husker will leave only about 3 ounces of husks on 100 pounds of ears, compared with about 7 or 8 ounces for a hook husker.

With both hook husking and peg husking, the typical method is for one man with a team and wagon to pick two rows across the field. The wagon is equipped on the side opposite the picker with a "bang board" about 3 feet high, against which the picker throws the husked ears.

In the matter of husking corn from the standing stalks, the farmers of Iowa, Illinois and Nebraska are the most efficient in the world. In most other sections of the world, the workers take nearly twice as long to husk 100 bushels of corn as do the farmers of the Corn Belt. The farmers of to-day are also twice as fast as their forefathers who followed the plan of having several members of the family husk into the wagon, throwing from both sides, and with a child picking up the down row.

Snapping corn.—Snapping is the breaking of the ear from the stalk, without removing the husk. This practice is common in the South, where corn dries out well and there is danger of injury in the crib from moths or weevils. In the Corn Belt, corn fed directly from the field early in the fall is snapped in order to save the labor of husking. Sweet corn is usually snapped and hauled directly to the cannery. Ordinarily, corn for cribbing is not snapped because:

1. The husks interfere with the drying of the corn in the crib.
2. The husks take up storage room.
3. The husks interfere with corn shelling, except in the case of big power shellers.

Husking by machine.—Corn-husking machines are being used more extensively each year in those sections where the fields are large and level and where ordinarily it is difficult to get labor for husking in November. The machine has been perfected to a point where it is remarkably successful in picking corn from down stalks. When weather conditions are favorable the husking machine leaves less corn behind in the field and less husks on the corn in the wagon than is the case with the average hand picker.

The great trouble with the machine is that within a few weeks after freezing weather, the shanks holding the ears to the

stalk become very brittle, and many ears fall to the ground very easily. It is universal experience that the mechanical picker gives best results in rather damp weather, provided the ground is dry under foot. Another objection to the mechanical picker is that it tears up the stalks so that there is little feed left on them for the stock.

In order for the picker to become a decided success in the larger corn-growing sections of the Corn Belt, it is essential

FIG. 8.—Husking machines give satisfaction under some conditions.

that tough shanked varieties of corn be developed. It will also help if the stalks are stiff and upright. Reid corn has a small, weak shank, which is ideal for hand husking, but poor for machine husking. There is a real opportunity for a corn breeder to develop a high-yielding strain of corn especially adapted to machine husking. Incidentally, it would seem that a two-eared type would be worth while for machine husking. Also the ears should be rather hard shelling, which probably means that the kernels would be rather shallow and smooth.

It may be well to have the ears carried lower on the stalk with machine husking than with hand husking.

The corn-picking machine of to-day husks about three-quarters of an acre an hour, the yield of the corn per acre having practically no influence on the speed. With a tractor equipped with a power take-off and a wagon hitch, it is possible for one man to drive the tractor which is pulling both the picking machine and the wagon. Another man and team are kept busy hauling and unloading. With a tractor it is possible to husk an acre an hour on the assumption that the tractor is traveling 2.5 miles per hour. With five horses on a machine, the typical speed after taking time out for adjustments is probably just a little less than two miles an hour, or about two-thirds of an acre an hour. Farmers with 100 acres of corn in fairly level fields have found it possible, figuring the cost of husking at 5 cents a bushel, to save enough to pay the necessary $400 for a corn-husking machine in three of four years. Other farmers who have no particular love for machinery have discarded their husking machines after one year of use. It is probable that those farmers with more than seventy acres of level corn to husk each year will become more and more interested in corn-husking machines, especially if varieties of corn are developed that are well adapted to machine husking.

Even now, corn-picking machines seem to have been sufficiently perfected to be a decided success on the larger farms where all conditions are favorable. All conditions are not likely to be favorable, however, for more than one-fourth of the time with the types of corn which are now most generally grown in the Corn Belt. There is a real opportunity for someone to develop types of corn genuinely adapted to the corn-husking machine.

In standing corn, during October, the machine seems to give better results than the ordinary husker, picking many nubbins which most huskers pass up and leaving less in the way of silks and ribbons on the corn in the wagon. But as the season wears on and the stalks become brittle and some of the

ears drop off, the machine seems to labor under a serious handicap. Ideal picking conditions are:

1. Upright hard-shelling corn.
2. Stalks and husks not too brittle.
3. Dry ground in the field.
4. Cloudy or damp weather.
5. Upright short stalks with ears carried low.

Heretofore, in the Corn Belt, corn breeders have selected the single-eared types of corn because of the greater labor of husking two-eared stalks. With the corn-husking machine, however, there may be a positive advantage in two-eared sorts.

With hand huskers, it is inadvisable for corn to carry the ears much lower than waist high, but with the machine it is permissible for the ears to be as low as 2 feet from the ground. For the picking machine, it seems that a rather smooth-kerneled, shallow-grained sort which clings tightly to the cob would be better than a deep-grained, rough, easy-shelling kind.

Reid Yellow Dent and other varieties of corn similarly bred are responsible for a large part of the difficulty with corn-picking machines. Reid Yellow Dent is an ideal variety for hand huskers as it carries a large ear on a small shank and breaks off easily. It is just about the worst possible variety for machine husking.

Even under ideal conditions, when the machine picks cleanly, there are some objections to the mechanical picker:

1. Five or six horses are required to pull the machine.
2. The machine is hard on the horses.
3. It tears down the stalks and leaves them in poor condition for pasturing.
4. It is expensive, costing about $400.
5. It is dangerous to hands if a man is careless.

Time required for husking.—According to the 1922 Yearbook of the United States Department of Agriculture, about the following number of bushels may be husked in a ten-hour day:

	Bushels
From shock, by hand, one man	45.0
From standing stalks, by hand, one man, two horses	85.0

A leading manufacturer of corn-husking machines claims that in fifty-bushel corn, two men, seven horses, a corn-husking machine and two wagons will husk at least 300 bushels, and probably 375 bushels in a ten-hour day.

Elevating the corn.—The larger Corn Belt farms usually have a portable elevator for delivering the husked corn from

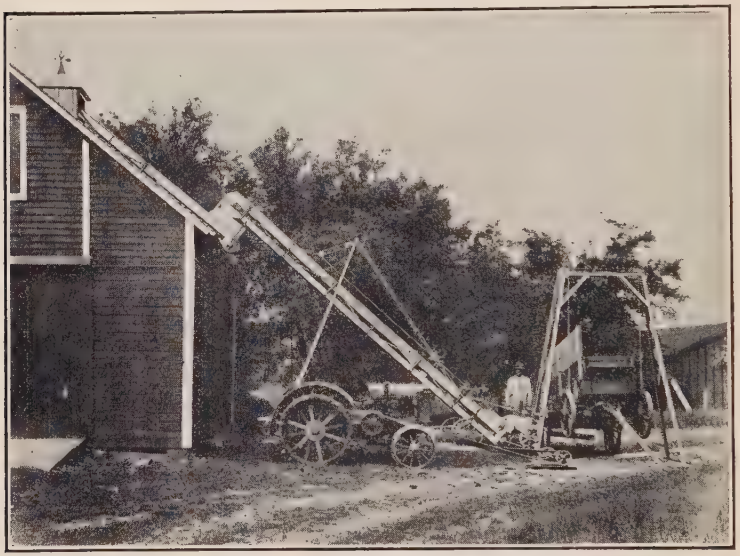


Fig. 9.—Cribbing corn with portable elevator.

the wagon to the crib. These elevators save a large amount of hand labor required when the corn is scooped by shovel from the wagon into the crib. The corn is dumped and elevated by power furnished by a team or gasoline engine. A crib may be entirely filled with no hand labor. For shoveling, the wagon is equipped with a special end-gate, which provides room for the shoveler to stand.

Storing the Corn

Corn Cribs.—A good corn crib should provide for the following:

1. Ventilation.
2. Protection from rodents.
3. Exclusion of moisture.
4. Accessibility to the feed lot.
5. Permanency.

Fig. 10.—A steel corn crib on a concrete base makes an ideal place to store corn.

Most of the cribs are of wood with slatted siding. These cribs are of varying lengths, but are quite uniformly 8 feet wide, so that good ventilation is obtained. In years of large corn crops, much corn is placed in temporary wire or stave fence cribs. For permanency, farmers have been building cribs of special hollow tile that has a channel extending downward toward the outside of the crib. These circular cribs with central ventilators and cement floors have proved very satisfactory.

Steel corn cribs have also been coming into use in recent years.

Moisture in corn.—It is not safe to crib, in an ordinary crib, ear corn that has more than 27 per cent moisture. In an average year at husking time, corn will contain from 20 to 30 per cent moisture. There is a rapid decrease during October and November in the amount of moisture in crib corn, and again in the spring months.

From November until the following October, corn will lose from 8 to 20 per cent in weight, depending upon conditions. As

FIG. 11.—A cheap, temporary corn crib which permits loss by weather and rats.

a rule, there will be about 17 per cent shrinkage in ordinary corn the first year. The second year there is a small amount of shrinkage in crib corn, usually less than 1 per cent. (See Chapter XXI.)

Measuring corn.—To find the number of bushels of shelled corn in a bin, multiply the length by the width by the depth (all in feet), and divide by 1.25. To find the number of bushels of ear corn, divide by 2.5. If the corn is in the husk, divide by 3.5. For a round crib, multiply the distance around the

crib by the diameter by the depth of the corn (all in feet) and divide by 10 to get the number of bushels of ear corn; if the corn is in the husk, divide by 14.5. A common wagon box is 10 feet long and 3 feet wide. It will hold two bushels of shelled

FIG. 12.—Illustrating inside elevator in a cement stave corn crib.

corn or one bushel of ear corn for every inch of depth. There are 2,150.42 cubic inches in a bushel of shelled corn, and 4300 cubic inches in a bushel of ear corn (allowing 70 pounds of ear corn to the bushel). In the case of unusually deep-grained, smooth-dented, well-matured corn, 3800 cubic inches of ear corn may shell out a bushel.

Shelling Corn

Ear corn containing not more than 25 per cent moisture shells readily, and in the frozen state corn with more moisture shells fairly well. However, it is not safe to bin shelled corn containing more than 17 per cent moisture. If shelled corn is to be stored beyond April 15, it should not contain more than 15 per cent moisture, or it is likely to heat seriously during the first spell of warm weather. Grade 3 corn, which contains not more than 17.5 per cent moisture, may be safely shipped in warm weather.

The two types of corn shellers are the spring sheller and the cylinder sheller. Most of the small power shellers and hand shellers are of the spring type. These shellers have an adjustable rag iron that holds the ears against a deep-grooved wheel that shells the corn from the ear as a large wheel revolves the ear, so that the kernels are removed from the entire ear. Blowers for cleaning, cob stackers, and elevators are part of most of the power types. The cylinder sheller is usually a large power machine. The corn is shelled by the revolving of shelling rings within a cylindrical cage. A common objection to this type of sheller is that it breaks the cobs and cracks the kernels. Large shellers of this type can shell as many as 350 bushels in an hour, and handle " snapped " corn fairly well.

Harvesting with Livestock

Every year more growers are harvesting part of their corn crop with livestock. In Iowa one acre out of every fourteen is harvested with hogs. Corn growers should give serious attention to the possibilities of harvesting at least part of their crop with livestock.

There are three general ways of harvesting the standing corn crop with livestock but hogging-down is the only common practice. These ways, in the order of their importance, are:

1. Harvesting with hogs—hogging-down.
2. Harvesting with sheep—sheeping-down.
3. Harvesting with cattle and horses.

Hogging-down.—Hogging-down corn is a practical and efficient way of gathering the crop and feeding spring pigs which are to be finished for the early winter market. Farmers who have tried it almost unanimously agree that the method is economical and successful. The most enthusiastic hogging-down men are those who have used the method longest. Tests show that hogging-down gives as good results as dry lot feeding.

FIG. 13.—Hogging down corn.

Advantages of hogging-down, according to the Iowa station, are:

1. Labor is saved.
2. Storage charges on corn are saved.
3. The hogs develop good constitutions.
4. No manure is lost.
5. The manure is evenly and uniformly distributed.
6. The crop is harvested without waste.
7. The weeds may be cleaned up.
8. Fall plowing is sometimes possible.
9. Corn is harvested more quickly.

The practice has some drawbacks, however. The disadvantages, according to the Iowa station, are:

1. The process hardens the soil if pastured when wet.
2. Some waste of corn occurs in wet weather.
3. Fencing is difficult.
4. Brood sows and gilts become too fat.
5. Takes extra care to turn hogs into new corn.
6. Heavy hogs may waste some corn.
7. Hogs do not gain well after hogging-down.
8. There is likelihood of neglecting hogs.
9. Hogs are more liable to sickness.
10. Stalks are hard to plow under.

Variety of corn to use.—The highest yielding corn which is adapted to the locality is the variety to use for hogging-down. The hogging-down season may be lengthened by having a small field of an early variety of corn on which to turn the hogs early in the fall. In the North, hogging-down is the only practical way of harvesting short-stalked varieties such as the early flints. Sweet corn does not produce as much pork as field corn, because it does not yield so well.

Supplements necessary.—Hogs in the cornfield must have protein in addition to that furnished by the corn if they are to make the most rapid and efficient gains. The cornfield weeds, such as lamb's-quarter, pig-weed, morning-glory, etc., furnish a little bone and muscle-building material, but not enough. Rape planted in the corn either at the time of the last cultivation or in the hill at corn-planting time furnishes enough growth when the season is favorable to supply part of the necessary protein. Soy beans planted with corn at corn-planting time usually increase the efficiency of the corn considerably. Tankage, however, seems ordinarily to be more effective and profitable than anything else in the production of rapid and economical gains on hogs in the cornfield. Experiments at the Ohio and Missouri stations indicate that it is almost as necessary to feed tankage to pigs on corn and soy beans as to feed it to pigs on corn alone. The following table gives the average results of five years' experimenting at the Missouri station in the hog-

ging-down of corn and of corn and soy beans, with and without tankage:

TABLE III

HOGGING-DOWN CORN AND SOY BEANS

(Average of five years' data—1919, 1920, 1921, 1922, 1923).

	Lot 1: Corn and Soy Beans (Supplemented by Tankage in Self-feeder)	Lot 2: Corn (Supplemented by Tankage in self-feeder)	Lot 3: Corn and Soy Beans (with no supplement)	Lot 4: Corn (with no Supplement)
Number of hogs per lot	13.00	13.00	13.20	12.80
Length of feeding period (days)	21.07	22.00	21.42	22.56
Average initial weight (pounds)	116.77	114.62	114.42	113.23
Average final weight (pounds)	153.59	154.54	137.38	134.75
Total gain (pounds)	478.20	518.80	303.15	276.25
Average daily gain per head (pounds)	1.74	1.81	1.07	.95
Total feed consumed (pounds)—				
Corn	1,703.50	1,949.90	1,694.60	2,138.00
Soy beans	247.20	.....	248.40	
Tankage	170.45	192.90		
Total	2,121.15	2,142.80	1,943.00	2,138.00
Average daily feed (pounds)—				
Corn	6.21	6.81	5.99	7.40
Soy beans	.90	.....	.87	
Tankage	.62	.67		
Total	7.73	7.48	6.86	7.40
Feed per 100 pounds of gain (pounds)—				
Corn	356.20	375.80	559.10	774.10
Soy beans	51.70	.....	81.90	
Tankage	35.60	37.20		
Total	443.50	413.00	641.00	774.10

It seems that farmers who will not feed tankage to their hogs in the cornfield will find it profitable to plant 3 or 4 pounds of soy beans per acre with their corn. If, however, they are prepared to feed from one-half to two-thirds of a pound of tankage per hog daily, there seems to be no gain from seeding soy beans with the corn.

At the Ohio station, as a three-year average, the following results were obtained:

TABLE IV

GAINS FROM ADDING SUPPLEMENTS TO STANDING CORN

	Standing Corn Containing Soy Beans	Standing Corn Containing Soy Beans Plus Tankage	Standing Corn Plus Tankage	Standing Corn Containing Rape Plus Tankage
Initial weight per pig (pounds)	147.50	147.60	146.90	147.30
Average daily gain (pounds)	1.08	1.73	1.78	1.88
Gain per bushel of corn (pounds)	8.89	13.23	12.62	12.89
Tankage with each bushel of corn (pounds)	.....	2.29	2.83	2.06
Value of gains per bushel of corn with cost of tankage deducted	$ 0.62	$ 0.86	$ 0.80	$ 0.84
Yield of corn per acre (bushels)	52.60	52.60	57.30	56 80
Gross returns per acre with cost of tankage deducted	$ 32.74	$ 45.14	$ 45.75	$ 47.75

Gains in live weight valued at $7 per cwt. and tankage at $60 a ton. The yields of the soy beans were not determined. Comparable plots showed soy beans, grown in the corn, to have reduced the yield of corn 4.7 bushels, and rape to have reduced the yield of corn .5 of a bushel per acre.

Defenders of the soy bean now claim that when minerals are fed to hogs on corn and soy beans much better results will

be obtained. This has not yet been fully proved, but the one thing which stands out clearly is that fattening hogs in the cornfield must have tankage to give the most economical results, no matter what is planted with the corn in the way of soy beans or rape.

Other Essentials.—It is essential that the hogs be put on a full feed of corn before being turned into the cornfield. It is a good practice to feed green corn fodder with the old corn so that the hogs may become accustomed to their new ration. The feeding of oats will help to counteract the laxative effects of feeding the green corn. If the hogs come in to pens at night, some old corn should be fed to them before they are turned out in the morning.

Hogs do better when an abundance of water and shade are provided. Clean, clear tile water is good if the land from which it comes is free from cholera and other contagious infection. Clear creeks of known source and fresh springs are good drinking places for hogs. The ordinary barrel waterer works well in most places. The value of plenty of clean, fresh water for hogs in the cornfield can not be over-emphasized.

Carrying Capacity of Corn.—Usually the field should be fenced in such a way that small areas may be harvested at a time. It is well to hog-off an area in three weeks, and better in two weeks. Spring shotes weighing 90 to 130 pounds are desirable for hogging-down corn. According to the Minnesota station, the number of days required to hog off an acre of corn with 125-pound pigs is:

Number of Pigs Weighing 125 Pounds	Approximate Number of Days				
	30-bu.-per acre Corn	40-bu.-per acre Corn	50-bu.-per acre Corn	60-bu.-per acre Corn	70-bu.-per acre Corn
10	22.5	30.0	37.5	45.0	52.5
20	11.2	15.0	18.7	22.5	26.2
40	5.6	7.5	9.3	11.2	14.1

Sheeping-down corn.—The practice of turning lambs into the cornfield at the rate of six or seven per acre, to clean up weeds and the lower leaves of corn, is a good one. Turning in twenty to forty lambs per acre to harvest the corn crop is more doubtful, for the reason that the lambs are ready to go back to market at the time when the fat lamb market is usually low, and, moreover, there is often some death loss when the lambs first begin eating corn.

In the latter practice, all the essentials, such as providing proper forage, water, shelter, fencing, salt, the right kind of animals, and proper management, are similar and equally important for sheep as for hogs. It is profitable to have addi-

FIG. 14.—Sheeping-down corn.

tional pasture and forage outside of the cornfield for the lambs. Plenty of rough feed should be supplied so that the lambs will not eat too much corn. The same forages, soy beans, cowpeas or rape, as sown in the cornfield for hogs, may be used for sheeping-down. At the Nebraska station, it was found advisable to feed the average lamb in the cornfield one-fourth pound of oil meal daily.

Thrifty lambs, weighing from 45 to 60 pounds, are desirable animals for sheeping-down corn. Older sheep are all right if not too defective in the teeth to eat corn readily. The feeders should be started slowly on the corn to keep down scours and bloat. Extreme precaution and common sense should be used in turning the lambs into the cornfield.

Lambs turned into the cornfield late in September will gain from 12 to 20 pounds per head in a feeding period of two or three months. During the feeding period the lambs will harvest 1 or 2 bushels of corn each, depending on the amount of supplementary feed. Small areas should be sheeped-down and the lambs moved before they have to hunt for feed. Shotes running with the lambs or turned into the field afterward will clean up the corn left by the lambs.

Harvesting with horses and cattle.—Horses and cattle may be used to harvest the corn from the standing stalks in the field. However, the disadvantages of packed soil, waste and fencing difficulties are more pronounced than in hogging-down. This method of harvesting is not a widespread practice, and is not used except in case of very cheap corn when husking is high-priced or labor is difficult to get. It is better to husk the corn fairly clean and turn in the horses and cattle to pasture the stalks and clean up the corn remaining in the field. A few farmers have claimed good results by turning hogs and cattle together into the cornfield. The cattle, in such cases, have been brought up to full feed before being turned in. After the cattle have cleaned up a little more than half of the corn, they are taken out and the hogs are left to clean up the rest. The cattle are then either sent to market or are kept on full feed for a short time and sent to market in early December.

Pasturing Cornstalks

A valuable by-product of the field-husked corn crop is the excellent pasture afforded by stalk fields after husking. A majority of Corn Belt farmers turn livestock into a corn field as soon as the field has been husked. A stalk field furnishes a good place to winter over cattle and horses. The livestock breaks down the stalks, aiding in preparation of the seed bed in the spring. Pasturing of stalks in wet weather is a disadvantage, however, especially on heavy soils, as the livestock pack down the soil.

CHAPTER III

MARKETING CORN

Eighty-five per cent of the corn crop is fed to livestock in some manner. In growing corn, therefore, it should constantly be kept in mind that livestock, in all probability, will be the final market. The outstanding problem of the Corn Belt is to obtain the greatest possible number of pounds of livestock from each acre of land at the least expenditure of human labor. Any step forward which results in the economic production of more bushels of corn per acre is fundamental to solving this problem.

The rich soil and favorable climate which make it possible to produce corn more abundantly and cheaply in the Corn Belt than any place else in the world, also make it possible for this section to produce fat livestock, especially hogs, more abundantly than any other part of the world. Fat, energy and heat-forming materials can be produced in corn of the Corn Belt with less outlay of man and horse labor than in any other grain.

Livestock Use of Corn

Balancing the corn ration.—While corn is the most important fattening grain, it has certain serious drawbacks. First, it is low in protein and ash—bone-and muscle-building material. Second, the protein which it does contain is largely zein and other types of protein which are inefficient for muscle-building and milk-giving purposes unless properly supplemented with feeds containing higher types of protein. Third, corn is relatively low in vitamins except the B vitamin. Yellow corn contains a little A vitamin, but white corn contains none. At

the Wisconsin station it has been proved that on good pasture containing plenty of vitamin A pigs would gain as well on white corn as on yellow corn. Tankage usually contains a little vitamin A, but not enough to supplement the complete absence of this vitamin in white corn. This was indicated by a Wisconsin pig experiment in the fall in which it was found that the white-corn pigs during the winter required for 100 pounds of gain 489 pounds of white corn and 59 pounds of tankage, whereas, the yellow-corn pigs required for 100 pounds of gain 439 pounds of yellow corn and 53 pounds of tankage.

Corn compared with other starchy grains.—The average percentage composition of some of the common carbohydrate grains, as given by Henry and Morrison, is given in Table V.

TABLE V

Composition of Ordinary Carbohydrate Grains

Grain	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	N.F.E.	
Dent Corn No. 3	16.5	1.4	9.4	1 9	66.1	4.7
Wheat	10.2	1 9	12.4	2.2	71.2	2.1
Oats	9.2	3.5	12.4	10.9	59.6	4.4
Barley	9.3	2.7	11.5	4.6	69.8	2.1
Rye	9.4	2.0	11.8	1 8	73.2	1.8

This composition shows that corn, wheat and rye each contain about 2 per cent fiber, whereas barley contains more than twice as much fiber as corn, and oats contain five or six times as much. In the case of hogs, each 1 per cent of excess fiber lowers the feeding value by 5 per cent. Fiber is not so important with horses and cattle, and for this reason oats are much more efficiently utilized by this class of livestock than by hogs.

Table VI, from "Feeds and Feeding," by Henry and Morrison, shows the average number of pounds of digestible

nutrients in 100 pounds and the nutritive ratio of the common grains:

TABLE VI

Comparison of Nutritive Value of Common Grains

Grain	Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Nutritive Ratio
Dent Corn No. 3	83.5	7.0	63.3	4.3	1 : 10.4
Wheat	89.9	9.2	67.5	1.5	1 : 7.7
Rye	90.6	9.9	68.4	1.2	1 : 7.2
Oats	90.8	9.7	52.1	3.8	1 : 6.2
Barley	90.7	9.0	66.8	1.6	1 : 7.8

Grinding corn.—One great advantage of corn as a feed for hogs is that ordinarily it is not so necessary to grind it as is the case with most other grains. Numerous experiments have proved that with dent corn the most profitable results can usually be obtained in hog feeding with either ear corn or shelled corn. With flint corn, or even semi-flint corn, this is not true. At the Illinois station, for example, it was found that Democrat corn, which is classed as a dent, although it is harder than most dents, did not feed out nearly as well as Silver Mine corn. The hogs on the softer Silver Mine ate about a pound of corn more per head daily and required about 8 per cent less feed to produce 100 pounds of gain. Big hog raisers in Argentina have discovered that they could not build up a profitable hog industry there until they substituted the softer textured dents for the hard flints. In Europe the Argentine flint corn is always ground before feeding to hogs.

With fattening steers, the practical plan is to feed the corn on the ear or shelled if there are hogs following to pick up the corn, about 10 per cent of which passes through whole. With no hogs following, it is best to grind for fattening steers unless corn is exceedingly cheap. For milk cows, it almost invariably

pays to grind. Horses with ordinarily good teeth handle corn on the ear to the best advantage. Fattening lambs are usually fed shelled corn, although toward the close of the feeding period it may pay to grind.

In future corn breeding work, it will be well to remember that the ultimate destination of most of our corn is livestock, and that most of our corn is fed on the ear or shelled. Since 1915, there has been a tendency to breed for a horny kernel which is supposed to be associated with higher yield and disease resistance. It must also be remembered that this can be carried too far and that a flinty kernel will make it necessary to grind the corn.

Comparable values of Corn Belt feeds.—The following table gives the comparative values of corn and other feeds based on chemical analyses, when nitrogen-free extract (starch) is valued at 1 cent per pound, fat at 3 cents and protein at 5 cents per pound:

Grains	Value Per Bu.
Corn, No. 3	$0.71
Oats	0.43
Barley	0.64
Rye	0.77
Wheat	0.84
Soy beans	1.57

Commercial Feeds	Value per Ton
Bran	$29.38
Standard middlings (shorts)	21.75
Hominy feed	28.26
Linseed oil meal (old process)	45.54
Cottonseed meal (39 per cent)*	50.26
Corn gluten feed	38.26
Corn oil cake meal	38.28
Molasses feed (10 to 15 per cent fiber)*	25.30
Soy bean oil meal	53.06
Tankage (60 per cent)	65.58
Molasses (blackstrap)	16.20

*Cottonseed meal is actually worth only about 85 per cent as much as this chemical analysis value. Molasses feed and molasses are probably worth somewhat more than the values given because of a certain palatability which they possess.

Barley, wheat and rye, if they are to have a feeding value as high in relation to corn as indicated in this table, must be ground.

In years of short corn crops, it may be advisable to value the nitrogen-free extract at 2 cents a pound or even more, whereas protein may still be worth 5 cents a pound. It is necessary therefore, to re-calculate this table if it is to fit changing conditions from year to year.

Fig. 15.—Half the corn of the Corn Belt is fed to hogs.

No animal can make satisfactory growth on corn alone. In the case of hogs, the bone-and muscle-building material in which corn is lacking may be supplied by small amounts of tankage, oil meal, dairy by-products, pasture, or alfalfa or clover hay. With cattle and sheep, oil meal, cottonseed meal, clover hay, alfalfa hay, or pasture most commonly supply the necessary protein and mineral matter.

Percentage of corn used by livestock.—Table VII indicates about what becomes of the corn crop in representative Corn Belt states:

TABLE VII

PERCENTAGE OF CORN CROP UTILIZED BY DIFFERENT ANIMALS*

	Iowa	Illinois	Nebraska	Indiana
Hogs	45	33	40	45
Cattle	14	13	13	14
Horses	11	15	14	13
Chickens	3	3	2	3
Shipped out (some of this is eventually fed to livestock)	27	36	31	25

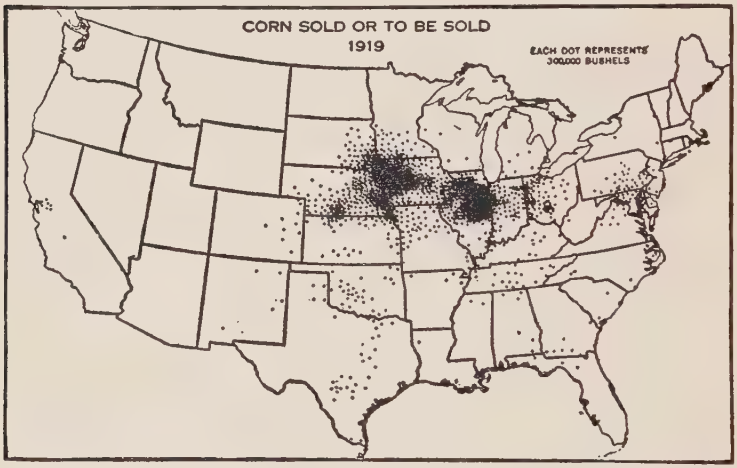
* In years of large corn crops and small hog population, the percentage utilization will be considerably different, but this table represents a fairly normal situation.

SELLING CORN AS GRAIN

About 250,000,000 bushels annually, or 15 to 20 per cent of the Corn Belt production, passes through such large primary corn markets as Chicago, Omaha, Peoria, Indianapolis, St. Louis and Kansas City. Chicago is outstandingly the largest of these primary markets, and normally receives over 100,000,000 bushels annually, or as much as any other four markets combined. Western Iowa, central Illinois and eastern Nebraska furnish over half of the corn which is received by the primary corn markets.

From farm to local elevator.—In northwestern Iowa, the typical method of handling the corn which is eventually sold at Chicago is described in the following: The farmer hauls his corn, either shelled or on the ear, to the local elevator. Most progressive farmers who have any large quantity of corn to sell prefer to shell at home, because they can haul a larger load of shelled corn. Moreover, they have the cobs to burn, and as a rule the elevator will pay them a cent or two a bushel more for shelled corn than for ear corn. The cost of hauling corn four or five miles is about four cents a bushel when man labor is 25 cents an hour and horse labor 13 cents an hour.

In November, December and early January, many elevators run a moisture test on the corn which they buy, especially in soft corn years. While the local elevators do not always buy corn on grade from the farmers, it is necessary at the start of each season for them to determine about how the typical corn in their respective communities will grade. If they find, as Iowa elevators found in December of 1917, that most of the corn is 22 to 26 per cent moisture, they know that



Courtesy of United States Department of Agriculture.

FIG. 16.—Most of the corn which comes on the terminal markets originates in central Illinois, northwestern Iowa and eastern Nebraska.

it will grade either as No. 6 or Sample grade on the Chicago market. They therefore pay the farmers the Chicago price for Sample grade corn minus freight to Chicago and the cost and risk of handling.

Price differential between corn on Iowa farms and at Chicago.—In the ordinary year, new corn in northern Iowa in December contains 18 or 19 per cent moisture, which permits it to grade as No. 4. As a rule, therefore, Iowa elevators during the early winter pay the Chicago price for No. 4 corn

minus freight and handling charges. The freight from north-central Iowa to Chicago previous to June 25, 1918, was about 7 cents a bushel. The rate was then raised until it reached 13 cents a bushel during the latter part of 1920 and during 1921. Since January of 1922, the freight has been 10.5 cents a bushel. It cost the ordinary country elevator about 3 cents a bushel to handle corn previous to 1917, and about 4.5 cents a bushel with costs as they have prevailed since 1922. This means that before the War the north-central Iowa elevator during the early winter usually paid the farmers for corn the Chicago price for No. 4 corn less 7 cents for freight and 3 cents for handling. In other words, with Chicago No. 4 corn at 60 cents a bushel, the north-central Iowa elevator paid 50 cents.

In the summer-time, when the moisture content in farm corn dropped to less than 15.5 per cent and the corn would therefore grade as No. 2 instead of No. 4 on the Chicago market, the north-central Iowa elevator would pay the farmers about 10 cents below the Chicago price for No. 2 corn. Since 1922, the standard differential between Chicago corn prices and prices paid by north-central Iowa elevators has been 10.5 cents (the freight rate) plus 4.5 cents (the handling charge), or a total of 15 cents. In December and January of many years, much of the new corn in the country grades No. 4 or even lower, and the prevailing farm price will be, under freight and handling charge conditions as existing since 1922, the Chicago price less about 18 cents.

In recent years there has been a tendency for the Chicago corn market to decline somewhat in relative importance. More and more corn is being moved direct across country without passing through the Chicago market. Such small markets as Cedar Rapids, Des Moines and St. Joseph have been growing. In the old days it was necessary to have grain pass through Chicago in order to have grades and weights certified to in a way which would command confidence in the minds of the consumers. To-day, very small markets can certify properly as to grades and weights. As a result of the development of other

markets than Chicago, there is an increasing tendency for corn on Iowa farms at times to sell above a parity with the Chicago market. In times of a short crop in the southwest, Iowa corn prices may even be temporarily within 8 or 10 cents a bushel of Chicago.

Types of country elevators.—There are three kinds of country elevators—independent, line and farmers' co-operative. The independent elevator is usually owned by a wealthy man in a small town who has an extensive acquaintance with farmers. Bankers, lumber dealers and feed dealers seem especially likely to embark on this line of business.

FIG. 17.—Typical country elevator.

The Federal Trade Commission reports that of over 9000 concerns handling grain at country stations in 1918, from which reports were secured, 36 per cent were commercial line elevators, 19.49 per cent were farmers' co-operatives, and 31.62 per cent were commercial independents. The local mills accounted for most of the balance. In several of the grain states, where there is a keen interest in co-operative marketing, the percentage of farmers' elevators is much higher than the general average of the country as reported by the Federal Trade Commission. For instance, Iowa's percentage of co-operative elevators was estimated at 32.6 in 1921. It should be noted also that the average farmers' elevator does business on a bigger scale than either of the other types. It buys annually on the average nearly twice the volume of the line elevator and about one-half more than the average independent. Ordi-

narily, an elevator should handle 100,000 bushels of grain annually if it is to do business on an economical basis.

Previous to 1900, many of the line elevators profiteered unmercifully, at the expense of their farmer patrons, and did all in their power to prevent the formation of co-operative elevators. Since 1910, the different types of elevators seem to have been doing business on about the same margin, with the tendency in favor of the co-operative elevators in years of rising prices, and oftentimes in favor of the line or independent elevators in years of falling prices.

Two ways in which country elevators may sell grain at Chicago.—Country elevators may ship their grain to Chicago as fast as they are able to fill the cars, or they may ship a little more leisurely and protect themselves against a decline in the market by " hedging " (selling short as many bushels of corn for future delivery as they have bought from the farmers). If the elevator does not take out any price insurance in the form of " hedge " sales, it will make a speculative profit above expectations in case the Chicago market advances before the car gets to it. On the other hand, there may be a speculative loss if the market falls. This speculative risk becomes very great in years of car shortage, which may cause the lapse of several weeks between the time the corn is purchased from the farmer and the time it is sold at Chicago.

When an elevator deals only in cash grain without any " hedge " insurance, it is necessary to pay about $15 a car (1 to 1.5 cents per bushel) for brokerage and miscellaneous charges. If, however, an elevator takes out " hedge " insurance by selling " future " corn at the time the purchase is made from the farmers, it is necessary to pay about one-fourth of a cent per bushel in addition for the insurance.

The method of hedging is illustrated in the following: An elevator is buying corn on February 20, which it expects to ship some time in March. May future corn, which is the nearest future, is quoted at 72 cents and the cash No. 3 corn is 66 cents. The elevator knows it must buy corn from farmers at

15 cents below Chicago price for the same grade, and it therefore pays 51 cents for 1115 bushels of corn, which is all that is offered to it that day. The same day it wires a commission company at Chicago to sell 1000 bushels of May corn at 72 cents (the 6-cent difference between the February cash No. 3 corn price and the May future is in part caused by contract future corn being No. 2 and in part by the two or three months' storage charges). When the corn is finally received in Chicago, on March 10, the price of the May future may be 65 cents and the cash No. 3 corn 59 cents. In that case, the elevator in buying back its paper contract on March 10, makes a profit of seven cents a bushel, which enables it to meet the loss on the cash corn. On the other hand, an advance to 80 cents for May future and 74 cents for No. 3 cash will result in a loss of eight cents a bushel on the paper corn, which counteracts the gain of eight cents on the actual corn. In either case, the net result is that the elevator gets for its corn a price about equivalent to what it paid the farmers on February 20.

The theory of "hedging" is attractive, and the practice is fairly good. Unfortunately, some elevator managers succumb to the temptation to buy and sell paper grain above what is needed for purely "hedging" purposes. In a few cases, also, the cash grain and future grain markets do not maintain the sympathetic relation toward each other which is necessary if "hedging" is to be perfect price insurance.

The four futures commonly dealt with on the Chicago market are May, July, September and December. The smallest unit of paper grain customarily handled is 1000 bushels. Commission firms charge one-fourth of a cent per bushel, or $2.50 for 1000 bushels, for the sale and purchase. In addition, it is necessary to put up with commission firms 10 cents a bushel, or $100 for 1000 bushels, to serve as margin to protect the commission company in case the corn goes up before the deal is closed. "Hedging" can be made really useful by elevator managers, especially when they are unable to ship promptly and when the tendency of the market seems downward. In the

case of line elevators, " hedging " is usually taken care of from a central office. Many co-operatives do not hedge at all, partly because they fear their managers may speculate on the side and partly because they do not understand the advantages.

The Grain Act, which was passed by Congress in 1922, gives the United States Department of Agriculture power to designate certain markets as contract markets where futures may be traded in. Regulations may also be prescribed with the idea of making it possible for the future grain prices to register actual

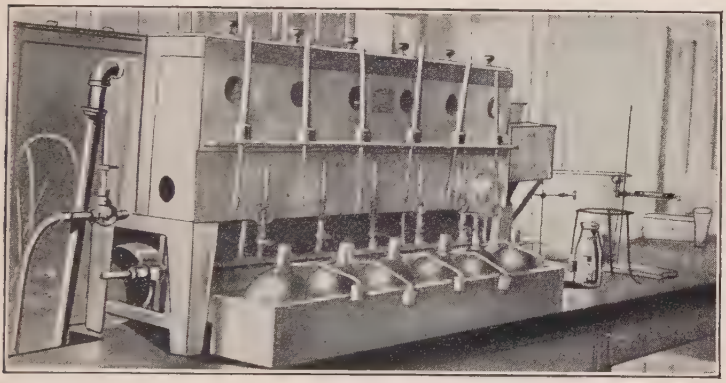


FIG. 18.—Moisture tester used in determining corn grades, both by country elevators and at primary markets.

changes in supply and demand conditions rather than mere speculative raids and corners. It is to be assumed, therefore, that the Grain Act may make it possible to use the Chicago market for " hedging " purposes with greater safety than would otherwise be the case.

Handling cash grain at Chicago.—Grain cars, when they reach Chicago, are switched onto grain tracks, where they are examined by state grain inspectors. Samples of grain are secured from each car and taken to a grain grading room where the percentage of moisture is ascertained and the corn is given a definite grade on the basis of the Federal Shelled Corn Standards, as set forth in Table VIII.

TABLE VIII

GRADE REQUIREMENTS FOR WHITE, YELLOW AND MIXED CORN

Grade	Minimum Test Weight per Bushel (Pounds)	Maximum Limits of			
		Moisture (Per Cent)	Foreign Material and Cracked Corn (Per Cent)	Total Damaged Corn (Per Cent)	Heat Damaged Corn (Per Cent)
No. 1	55	14.0	2	2	.1
No. 2	53	15.5	3	4	.1
No. 3	51	17.5	4	6	.3
No. 4	49	19.5	5	8	.5
No. 5	47	21.5	6	10	1.0
No. 6	44	23.0	7	15	3.0
Sample					

NOTES.—Sample grade shall be white corn, or yellow corn, or mixed corn, respectively, which does not come within the requirements of any of the grades from No. 1 to No. 6, inclusive, or which has any commercially objectionable foreign odor, or is heating, hot, infested with live weevils or other insects injurious to stored grain, or is otherwise of distinctly low quality.

The corn in Grades Nos. 1 to 5 shall be cool and sweet.

The corn in Grade No. 6 shall be cool, but may be musty or sour.

Weevily Corn—Weevily corn shall be all corn that is infested with live weevils or other insects injurious to stored grain.

Grades for Weevily Corn—Weevily corn shall be graded and designated according to the grade requirements of the standards applicable to such corn if it were not weevily, and there shall be added to, and made a part of, the grade designation, the word "Weevily."

Definitions of Standards.—For the purposes of the official grain standards of the United States for shelled corn (maize), the following definitions obtain:

Corn.—Corn shall be shelled corn of the flint or dent varieties.

Basis of Determinations.—Each determination of color, damage and heat damage shall be upon the basis of the grain after the removal of foreign material and cracked corn as provided in the section defining foreign material and cracked corn. All other determinations shall be upon the basis of the grain, including such foreign material and cracked corn.

Percentages.—Percentages, except in the case of moisture, shall be percentgaes ascertained by weight.

Percentage of Moisture.—Percentage of moisture in corn shall be that ascertained by the moisture tester and the method of use thereof described in Circular No. 72 and supplement thereto, issued by the United States Department of Agriculture, Bureau of Plant Industry, or ascertained by any device and method giving equivalent results.

Test Weight per Bushel.—Test weight per bushel shall be the weight per Winchester bushel as determined by the testing apparatus and the method of use thereof described in Bulletin No. 472, dated October 30, 1916, issued by the United States Department of Agriculture, or as determined by any device and method giving equivalent results.

Foreign Material and Cracked Corn.—Foreign material and cracked corn shall be kernels and pieces of kernels of corn, and all matter other than corn, which will pass through a metal sieve perforated with round holes $\frac{2}{64}$ inch in diameter, and all matter other than corn remaining on such sieve after screening.

Heat-damaged Kernels.—Heat-damaged kernels shall be kernels and pieces of kernels of corn which have been distinctly discolored by external heat or as a result of heating caused by fermentation.

Market corn is also divided into classes on basis of color, as follows:

White Corn.—This class shall consist of corn of which at least 98 per cent by weight of the kernels are white. A slight tinge of light straw color or of pink on kernels of corn otherwise white shall not affect their classification as white corn.

Yellow Corn.—This class shall consist of corn of which at

least 95 per cent by weight of the kernels are yellow. A slight tinge of red on kernels of corn otherwise yellow shall not affect their classification as yellow corn.

Mixed Corn.—This class shall consist of corn of various colors not coming within the limits for color as provided in the definitions of white corn and yellow corn. White-capped yellow kernels shall be classified as mixed corn.

In the ordinary crop year, the leading primary markets receive about equal amounts of No. 2, No. 3 and No. 4 grades of corn, with much more No. 3 and No. 4 corn coming in during December and January. In a soft corn year like 1917, 25 to 40 per cent of the corn may be soft corn and sell 5 to 15 cents a bushel below No. 2. In unusually sound corn years like 1920, half of the corn may grade as No. 2 or better.

As to price differences on grades, the Chicago Board of Trade has the following rule:

> For delivery on and after May 1, 1927, all contracts for corn, unless otherwise specified, shall be understood as for "contract" corn, and on such contracts a tender of the following described grades of corn, in such proportions as may be convenient to the seller, but in no case an amount less than 1000 bushels of any one grade in one elevator, shall be deemed a valid tender at the price differences mentioned in the following schedule, subject, however, to the provisions of Section 5 of Rule XXI:
>
> No. 1 white corn, No. 2 white corn, No. 1 yellow corn, No. 2 yellow corn, at ½ cent per bushel over contract price.
>
> No. 1 (mixed) corn, No. 2 (mixed) corn, at contract price.
>
> No. 3 white corn, No. 3 yellow corn, at 2 cents per bushel under contract price.
>
> No. 3 (mixed) corn, at 2½ cents per bushel under contract price.

Utilizing Soft-corn Crop

Handling soft corn is a serious problem over large sections of the northern part of the Corn Belt, in such years as 1902, 1915, 1917 and 1924. Bad soft-corn years are foreshadowed long in advance by cold, wet summer weather. After a summer of this sort, it is only rarely that dry, warm weather in September and October will avert the threatened danger.

In the typical soft-corn year at the time of the first killing frost in late September or early October, about one-fourth of the ears will be in the milk stage, containing about 60 per cent moisture; one-fourth will be rather soft but somewhat dented, containing 45 to 55 per cent moisture; one-fourth will be well dented, but rubbery, containing 40 to 45 per cent moisture; and one-fourth will be solid, well-matured ears, containing 30 to 40 per cent moisture. In the ordinary season, the last two classes, containing 30 to 45 per cent moisture, will be down to less than 25 per cent moisture by Thanksgiving time, and can be cribbed with safety. Corn which is doughy or milky, however, at the time of the first killing frost, dries out very slowly unless October and early November are unusually dry and warm. Ordinarily, this doughy or milky corn still contains 25 to 35 per cent moisture in late November or early December. By that time it will have become dented and somewhat chaffy as a result of partial drying, but it will still contain too much moisture as a rule to keep without molding, heating or discoloration when stored in the ordinary crib.

Cribbing soft corn.—Farmers prefer to store most of their corn in the crib if it is at all practicable. They know that in a soft corn year about half the ears will heat and mold if put into the ordinary crib at husking time in November. To get around the difficulty, they use various devices. First, many of them divide their wagon box, when husking, into two parts and throw the soft corn into one part and the cribbable corn into the other. Others vary this plan by making the separation into soft and cribbable corn at the crib at the time the wagon is being unloaded. When this plan is followed, the soft corn is fed out or sold in a few weeks. Second, many farmers put extra ventilators into their cribs. Strings of 6-inch tile laid every 2 or 3 feet crosswise of the crib answer the purpose very nicely. Other types of ventilators are suggested in the accompanying illustration from Illinois Circular No. 293. Two ventilators of the sort illustrated are usually laid horizontally after about 2 feet of corn have been put in the crib, and then after

about 2 feet more of corn have been spread two more ventilators are put in, and so on. Some farmers make vertical ventilators somewhat resembling chimneys, by using 2 × 4's about a foot apart each way and connected with 1 × 3 slats. These vertical shafts are sometimes connected up with horizontal strings of tile. The idea in any scheme of ventilation is to have all of the corn within at least 2 feet of the air.

A third plan is salting. This has been used by a number of farmers in Illinois. Tests by Hughes, of the Iowa station, indicate that 1 pound of salt per hundred bushels of corn helps

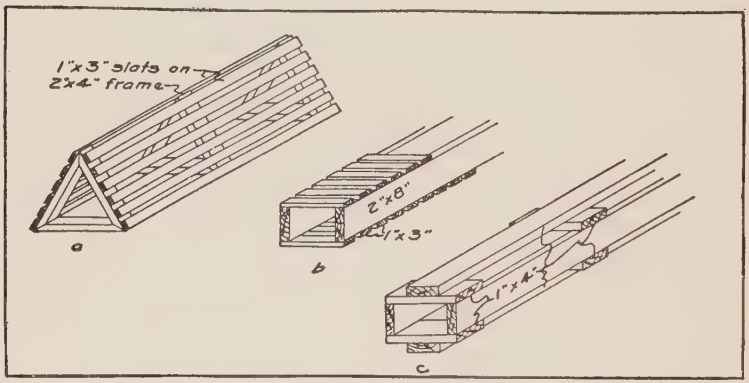


Fig. 19.—Crib ventilators of this type can be used in either a vertical or a horizontal position in the crib.

considerably in reducing mold in the case of corn which contains 30 per cent moisture at cribbing time. Two pounds of salt per 100 bushels are more effective, but such heavy salting is not wise when the corn is to be fed to livestock. Salting should always be used in connection with one of the ventilating devices as is described in the foregoing. The method of salting is to spread a layer of salt with each $1\frac{1}{2}$ foot layer of corn. Hughes has also proved that salting is valuable in preventing heating in shelled corn containing 30 per cent moisture. With both salting and ventilation of cribbed corn, it is a help if the

corn is husked cleaner than usual, with the minimum of husks and silks.

A fourth plan, much used by practical farmers, is to delay cribbing in a soft-corn year until the late winter. The ordinary winter allows the soft corn to dry out very nicely on the stalk. In 1917, a number of farmers followed this plan, husking their corn as they needed it, and storing only a rather small quantity of corn in the crib at the regular time in November. Farmers who husked in March of that year claimed that their soft corn was so well dried out that it kept perfectly through the summer in the ordinary crib without any special ventilation.

Shocking soft corn.—With the corn binder it is possible to cut up about eight acres a day, and in a soft-corn year, the average farmer with forty to sixty acres of corn and fifteen to twenty cattle, will find it worth while to cut up fifteen or twenty acres, or even more, in case he has no silo. The stalks in a soft-corn year contain a higher percentage of the food value than usual. The shocks should be made a little smaller than usual in a soft-corn year in order to permit more rapid drying.

Siloing soft corn.—For the man who has livestock, the silo is the ideal place to store soft corn. On most farms, however, the silo will hold only about one-fourth the crop. One way around the difficulty is to refill the silo in January or February with dry corn fodder, adding 100 pounds of water for each 100 pounds of dry fodder. This plan is not satisfactory if delayed until early spring. Another method of increasing the holding capacity of the silo in a soft-corn year is to put into the silo only the snapped ears. About twice as many acres of snapped corn can be put into the silo as of ordinary silage corn. Feeding tests at both the Iowa and Illinois stations have demonstrated that silage made out of either snapped soft corn or husked soft corn is of high feeding value. The greatest drawback of this plan is that the feeding value of the stalks is lost to a considerable extent, and this is a serious loss because in a soft-corn year the stalks are of higher feeding quality than usual. Practical farmers have been slow to follow the practice of

siloing soft ear corn in spite of the favorable experiments at the Iowa and Illinois stations.

Shredding.—Shredding soft corn is usually unsatisfactory. It is hard to shred because it is sappy, and, furthermore, if it is not well dried out it will spoil in storage. Some farmers recommend the addition of salt, about 5 to 20 pounds to the ton. If necessary to shred, it is well to shred often, and not store too large a quantity of shredded material. It is well to put off the shredding to the latest possible date, so that the corn will be well dried out in the shock.

Use of heat.—Soft corn has been dried out in the crib at a low cost by a method originated by the Iowa station. Ven-

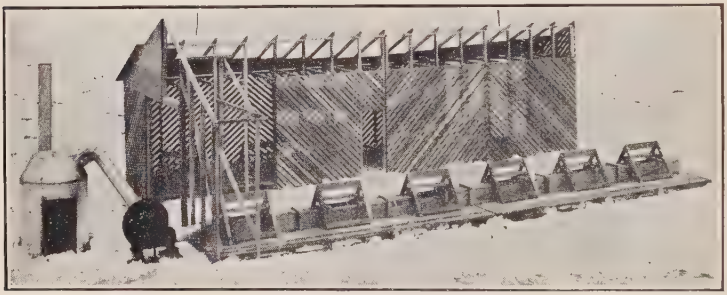


FIG. 20.—Model of the Hughes hot-air drier, which has been used very successfully in making soft corn cribbable.

tilators are placed underneath a crib and heat is forced through the corn by means of a hot-air furnace and blower. A series of trap doors allows drying out of small sections of the crib at one time. In tests, the moisture content of crib corn was reduced from over 30 per cent to less than 10 per cent, at a cost for fuel and power of less than 5 cents a bushel.

This plan of forcing heated air through the corn in the crib has not come into extensive use because of the large investment in the furnace and because ordinarily a really calamitous soft-corn year necessitating such expensive apparatus, if the corn is to be kept in the crib, comes only about once in ten years.

Farmers in the northern part of the Corn Belt, who grow over 100 acres of corn and sell a high percentage of their crop on the market, will find it worth while to look into this Hughes plan of hot-air drying. Most farmers will not find it practical.

Marketing.—In marketing soft corn, it is well to shell in a frozen condition and haul to market in the frozen state. Inasmuch as a premium is paid for the most mature, hardest corn, it is well to sell that and feed the soft ear corn. It is surprising how much water in a frozen condition ear corn can carry in the grain. Even though not frozen, corn with as much as 25 per cent moisture shells readily.

Feeding.—Feeding soft corn is the most logical method of disposition. There are two essential precautions: Feed early while the quality is still good, and feed often—three, four and more times a day. Moldy corn is dangerous for horses and young sheep. But hogs may usually be trusted to eat what they will.

"Moldy corn," says Dr. R. E. Buchanan, "has often been suspected of poisoning cattle and hogs. Investigations carried on in recent years seem to indicate, however, that this rarely, if ever, occurs. The diseases or sicknesses of cattle which once were supposed to be due to mold poisoning have since been found to be due to infection with hemorrhagic septicemia or other diseases which have nothing whatever to do with mold on corn. It seems, therefore, that there is no good reason why corn showing more or less mold can not safely be fed to cattle and hogs.

"The molds which appear are sometimes blackish, sometimes bluish, greenish or pinkish in color. If these molds are not present in excessive amounts, that is, if the corn is not actually rotten or matted together by the mold, it is not probable that cattle and hogs will be injured by eating it.

"What has been said above, however, should not be used as justification for feeding moldy corn to horses. Many instances are on record of horses being killed by eating moldy silage, moldy corn, and moldy forage of other types. Whether or not

it is the mold itself or some other organism growing in the moldy corn that causes the trouble is at present uncertain."

Evvard found at the Iowa station that with soft corn containing 25 per cent moisture hogs required for 100 pounds of grain 495 pounds of soft corn and 47 pounds of tankage, whereas the same kind of hogs fed at the same time with old corn containing 14 per cent moisture, required for 100 pounds of gain 432 pounds of old corn and 34 pounds of tankage. The dry matter in soft corn has about the same chemical composition as the dry matter in old corn, but for some reason animals fed on soft corn crave more protein than animals fed on sound corn. It seems to be wise, therefore, to feed a little more tankage than usual to hogs on soft corn and a little more oil meal than usual to cattle on soft corn.

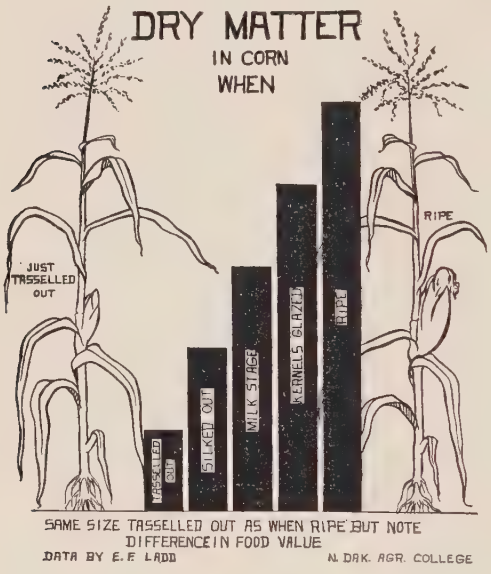


Fig. 21.

Buying soft corn.—The feeder who has a choice between buying No. 2 or No. 3 corn, containing 15 to 18 per cent moisture, and soft corn of sample grade, containing over 23 per cent moisture, oftentimes does not know what to do, especially when he can buy the soft corn at 20 cents a bushel less. A safe guide is to figure out the cost of a pound of dry matter in the two grades and then to choose the high-grade corn unless a pound of dry matter can be bought in the soft corn for less than 90 per cent as much as in the sound corn. If the soft corn is

moldy or discolored, it should not be bought unless a pound of dry matter can be bought in it for less than 80 per cent as much as in the sound No. 2 or No. 3 corn. In fact, there are some grades of soft corn which are practically worthless, even after their high moisture content is taken into account. Ordinarily, however, soft corn containing 25 per cent moisture, which is not moldy or discolored and which can be fed out before there is any danger of spoiling, is worth to the feeder about 80 cents a bushel on the same basis as No. 2 corn is worth $1 a bushel.

Chemical analysis of corn at different stages.—The yield of dry matter in corn at different stages, on the acre basis, as figured from Indiana results of Jones and Huston, on a basis of 100 as final mature yield, is given in Table IX.

TABLE IX

YIELD OF DRY MATTER IN CORN AS RAISED IN INDIANA

Stage of Growth	Corn Plus Cob (Ear)	Stalks, Blades, Husks, etc.—Stover	Entire Corn Plant
Four feet high	.....	.....	7.76
First tassels	.....	.....	23.85
Silks drying, kernels forming	14.56	90.21	48.53
In the milk	43.73	92.41	65.59
In the glaze	74.56	100.00	86.11
Well dented	89.19	101.84	94.87
Ready to shock	100.00	100.00	100.00

In the early kernel stage, less than 15 per cent of the dry matter found at maturity has been laid down in the ear, and only 44 per cent in the milk stage. If frost comes when the milk still shows plainly, the yield is approximately half in dry matter, as compared to the normal matured yield. The stover contains more than 90 per cent of the total possible dry matter as early as the milk stage. Therefore, in frosted corn the greatest damage in yield is to the ears.

CHAPTER IV

TESTING, GRADING AND ADAPTING SEED CORN

If seed corn is picked before freezing weather and stored in a dry, well-ventilated place and protected from freezing temperatures until it is well dried, there is no need of seed-corn testing. But in order to be absolutely safe, every farmer, in February, should germinate two hundred kernels of corn from two hundred ears taken at random. If less than 90 per cent of these kernels grow strongly, it will almost certainly pay the farmer a dollar an hour for his time to make a thorough ear by ear test of all the ears which he expects to plant.

Rag Doll Test

The cheap and efficient rag doll.—The rag doll seed corn germinator, according to Hughes, of Iowa, made possible a satisfactory corn crop throughout all of the Corn Belt in 1918, when we were at war and when a failure in our corn crop would have been a national disaster. Seed corn fit to plant was not to be had in any quantity, perhaps not enough to plant one-tenth of the corn crop. The only means of getting good seed was by testing millions of individual ears, separating the good from the bad. The doll germinator was used in making practically all of these tests.

The ear-by-ear test may be made easily with the rag-doll tester, which is the simplest of all the home-made testers. To make and fill a forty-ear rag-doll tester:

1. Tear sheeting into strips 12 inches wide and 60 inches long.
2. Spread the cloth lengthwise on table and rule through the middle

and crosswise every 3 inches, leaving 5 inches on each end. This makes twenty squares on each half of the doll.

3. Number the squares, with "1" in upper left-hand corner, "2" in upper right-hand corner, "39" in lower left-hand corner, "40" in lower right-hand corner.

4. Write numbers corresponding to the forty ears being tested on the back of the left-hand end of the cloth.

5. Thoroughly wet the cloth and spread it smoothly on the table, with Square No. 1 at the left.

6. Remove six kernels from representative parts of Ear No. 1 and place in Section No. 1 of the cloth; and so on for the forty ears.

7. Use a stick or roll of paper the diameter of a pencil, around which to roll the cloth.

8. Roll the cloth carefully, but not too tightly, beginning at the right-hand end.

9. Place a cord or rubber band loosely around the middle and firmly around each end of the rag doll.

10. Soak in lukewarm water for five to ten minutes.

(See page 140 for description of use of rag doll in eliminating moldy and diseased ears.)

After soaking, turn a bucket upside down over the dolls, keeping them from drying out while the kernels are given time to germinate. If placed in a pail, the dolls should be raised so that the lower end will receive sufficient air and not stand in the water. If the dolls are stood up, the sprouts will grow toward one end and the roots toward the other, making the test much easier to read than where the dolls are allowed to lie flat. This method also insures better drainage and better ventilation. It is also well to put a wet piece of gunny sack or other coarse cloth around the dolls to prevent them from drying out. The dolls should be sprinkled often enough to keep them moist. They should be kept at room temperature, 60 to 80° F. The end bands should be removed after two days, to allow sufficient room for growth. In five or six days, the germination test should be ready to read.

To read the test, carefully unroll the doll. Examine all kernels closely. In case all six kernels do not show strong germination, the ear should be discarded. There is danger of

discarding as worthless, however, ears called "slow germinators," which, though backward in germination, are practically as strong as any. At the Iowa station, ears which when tested and read as having six weak kernels, gave a higher stand and a greater yield in tests than any other class of ears with the exception of those read as six strong. If seed is very scarce, it may be well to save ears showing not more than one dead kernel out

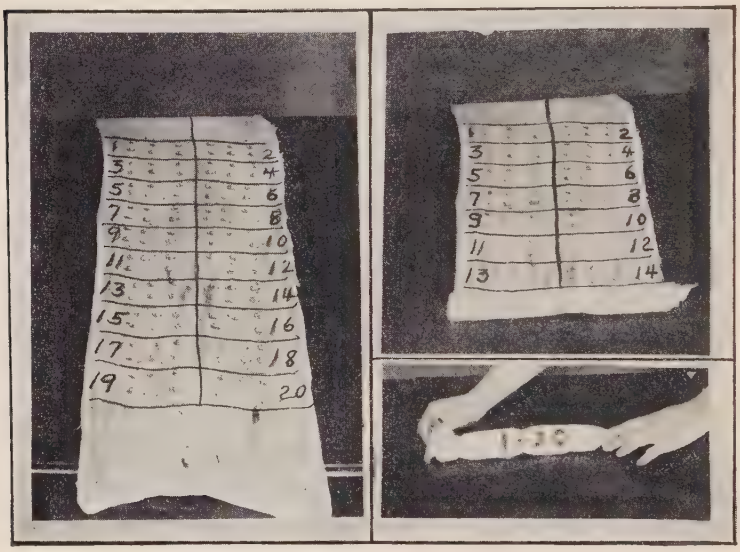


FIG. 22.—Rag doll seed-corn tester.

of the six tested. Table X gives the stand and yield obtained by the Iowa station when ears of different germinating power were planted in separate plots, but under the same soil and climatic conditions:

On the basis of this experiment, we would expect corn, which in the preliminary 100-kernel test stood 57 strong, 37 weak and 6 dead, to yield about 43 bushels per acre, as compared with 45.7 bushels for really strong corn. Incidentally, it should be stated that in 1911 the weather was exceptionally warm in

May, June and July, and thus favored low-testing corn more than usual. In 1910, when this same experiment was conducted the weather in May and June was very cold and the margin in favor of the high-testing ears was much greater than in 1911. In the ordinary season it is safe to say that ear-by-ear seed-corn testing pays at the rate of at least one dollar an hour unless the preliminary test indicates that 90 out of each 100 kernels will grow strongly and that not more than six out of the 100 are dead.

TABLE X

STAND AND YIELD TESTS OF CORN FROM SELECTED SEED EARS IN IOWA

Average of Two tests by Iowa Station in 1911.

Germination			Stand Per Cent	Yield Bushels
Strong	Weak	Dead		
6	0	0	73.9	45.7
5	0	1	66.4	43.4
4	0	2	59.4	41.0
3	0	3	53.2	37.6
2	0	4	43.0	32.2
5	1	0	70.4	44.4
4	2	0	68.6	44.0
3	3	0	68.2	43.6
2	4	0	64.1	41.4
1	5	0	68.0	44.1
0	6	0	71.0	44.8

Cost of testing.—The cost of testing individual ears of corn for germination depends upon the method used and the efficiency of the operator. From the tests made at the Iowa experiment station, the cost has been found to be from 15 cents to 45 cents for each one hundred ears. The difference was due entirely to the method of testing which was employed. The cost of testing corn by the rag-doll method was 18 cents and by

the sawdust box method, 27 cents. This was on the basis of pre-war values.

The cost of selecting seed for planting an acre will depend upon the method used and the quality of the corn. If the corn is of fair quality so that it is not necessary to throw away too many ears, the testing cost per acre will be less than 10 cents. And even if the corn is of such poor vitality as to make it necessary to throw away 85 per cent of the ears, the total cost of getting out enough for an acre will not be over 25 cents.

What to do if low-testing corn must be planted.—Even though corn with a general test as low as 60 per cent must be planted, the effect on the yield is not necessarily very serious, provided the farmer knows that he is planting low-testing corn and increases his rate of planting accordingly. If the farmer would plant 100 per cent corn at the rate of three kernels per hill, he should plant 60 per cent corn at the rate of five kernels per hill in order to get as many live kernels planted on each acre as with good corn. According to the theory of probabilities, 17,500 kernels of 60 per cent corn planted on an acre of 3500 hills would result approximately in:

36 hills with 5 dead kernels.
272 hills with 5 live kernels.
907 hills with 1 dead and 4 live kernels.
269 hills with 4 dead and 1 live kernel.
1,210 hills with 2 dead and 3 live kernels.
806 hills with 3 dead and 2 live kernels.

If the live kernels from 60 per cent corn grew as vigorously as from 100 per cent corn, the yield should not be affected by more than two or three bushels per acre by such a distribution as the above. At any rate, at the Nebraska station, as a five-year average, it was found that alternating hills of one, two, three, four and five plants yielded at the rate of 58.6 bushels per acre, as compared with 59 bushels where every hill contained three plants. One of the greatest objections to planting 60 per cent seed corn is that the hills with four to five stalks have a rather high percentage of nubbins. Of course the plant-

ing of poor seed corn thickly is attended with considerable risk, and this plan should never be followed unless the only alternative is buying unacclimated seed. It is better to plant home-grown seed corn of low-germinating power thickly than it is to buy high-germinating corn from a distance.

Shelling and grading seed corn.—Ideally, each ear should be shelled by hand, each ear going into a pan by itself before it is dumped into the sack with the rest of the corn. In this way, ears with moldy and dull, starchy kernels may be detected and thrown out. Ears with blistered germs and shrunken kernel tips can also be thrown out. If the job of shelling seed corn by hand is done conscientiously, it is easily possible to earn wages of one dollar an hour, and especially is this true if the corn has not been given a careful ear by ear germination test. Experiments at Ames indicate that it is much easier to judge the yielding power of an ear of corn by looking at its shelled kernels than by looking at the ear itself. Shelling corn by hand gives the time required to judge kernel type effectively. It may also avoid a few broken kernels, but this is not at all important. In fact, experiments reported by Bulletin No. 1011 of the United States Department of Agriculture indicate that corn kernels will stand an astonishing amount of mutilation and still grow fairly normally.

After shelling, it helps a little to run the corn over either a cheap hand grader or a cylinder machine grader. Iowa experiments indicate that size of kernel is one of the most important things in determining yield. The light, small kernels are often poor yielders. Theoretically, therefore, the eliminating of the small kernels with a grader should be decidedly worth while. And, of course, kernel uniformity is of real help in getting the best results out of the corn planter.

Obtaining a better variety.—The best varieties are usually those which have been grown so long in a community that they are thoroughly adapted to the soil and climate. However, it often happens that higher yielding sorts can be brought in from outside especially if the soil and climate are similar. If

the soil and climate are different it may take several years to acclimate the newly introduced sort to the point where it will yield as much as the home varieties.

The Adaptation of Corn

Length of season.—Corn must be well adapted to the probable length of season if it is to yield well. Under long season conditions, the corn plants which seem to yield best are rather tall and leafy and the kernels tend to be either large or deep. At the Nebraska station, in the same field side by side, a strain of Reid Yellow Dent which had been developed in southern Nebraska was grown in comparison with another strain of Reid which had been developed one hundred miles farther north, in north-central Nebraska. The plants of the northern Reid were 1 foot shorter; the ears were nearly an inch shorter, and the ear circumference was one-third of an inch less. The kernels of the northern corn, even when grown under the same conditions as the southern corn, were slightly more shallow and the shelling percentage was 82 per cent for the northern corn and 85 per cent for the southern. The smaller stalk and ear made it possible for the northern Reid to ripen a week or ten days earlier than the southern Reid.

In the latitude of Iowa and the states to the north of Iowa there is always risk when seed corn is moved north or south by one hundred miles or more. It should be said, however, that when Krug corn was brought from Woodford county, Illinois, one hundred miles north to Story county, Iowa, the yield the first year was very good, much better, in fact, than the majority of the Story county varieties when grown side by side on the same farms. It happens, however, that both so far as summer temperatures and length of corn-growing season are concerned, Woodford county, Illinois, is almost identical with Story county, Iowa. It would seem to be quite safe to move a high-yielding strain one hundred miles north or south, provided that the climatic conditions are nearly the same. Corn from central

Illinois has nearly always done well in central Iowa, even though central Iowa is one hundred miles farther north. But when corn in central Illinois is moved one hundred miles north into northern Illinois, where the summer temperatures average two or three degrees lower and the season is a week or two shorter, the result is oftentimes soft corn. Moving northern corn south one hundred miles may not cause quite as serious trouble as moving southern corn north, but as a rule the yield is 15 or 20 per cent less than would have been obtained with a variety of corn which had become accustomed to utilizing the slightly longer season.

Effect of soil differences.—Farmers know that there are some varieties which yield splendidly on a certain farm, but yield poorly on another soil type only fifteen or twenty miles away. They know that on rich land Reid Yellow Dent is one of the best varieties in the central part of the Corn Belt, but on poor land many of them favor white varieties, especially Silver Mine.

Experimental work by Hoffer, at the Indiana station, indicates that some strains of corn are much more likely than others to absorb harmful aluminum and iron from the soil when they should be absorbing phosphorus and potash. It seems that on rich soil certain strains of corn are not at all susceptible to iron and aluminum injury, whereas on poor soils they are decidedly susceptible. The work at the Indiana station may eventually provide a scientific explanation of the practical fact recognized by farmers that some varieties are adapted to poor land and some to rich land. When this explanation finally is available, it may be possible to breed corn more definitely for poor and rich land conditions than is possible to-day.

Effect of moisture and leaf size.—It seems that corn plants with broad, long leaves tend to give a slightly higher yield, other things being equal, when there is plenty of moisture. In dry seasons, however, the advantage is with the narrow-leafed plants. East of the Missouri River the balance between wet and dry seasons is such that it does not seem to make much

difference whether broad- or narrow-leafed plants are favored. It is in such states as Nebraska and Kansas that the moisture situation is really acute.

Professor Kiesselbach, of the Nebraska station, has found that there is a very definite tendency for the plants with a low-leaf area to give a higher yield than those with a high-leaf area. The amount of moisture given off by corn plants varies almost directly with the leaf area, and if the moisture is limited, there may be a decided advantage in rather narrow leaves. At the Nebraska station, Kiesselbach has found that the low-leaf area strains are associated with rather long, slender, smooth ears with shallow grain, whereas the high-leaf area strains tend to be associated with rather short, fat ears with deep and somewhat rough kernels. It is possible that this rough type may yield more than the other when plenty of moisture is available; but when the moisture is not available, Professor Kiesselbach's experiments indicate that the low-leaf area strains have an advantage of 5 or 6 bushels per acre over the high-leaf area strains under Nebraska conditions.

There have been a great many experiments at the Nebraska station comparing the yielding power of corn imported from Iowa, Illinois, Indiana and Ohio with the strains developed locally. Occasionally in a favorable season the imported seed has yielded practically as well as the Nebraska-grown seed, but in the average season, and especially in the dry seasons, the locally grown seed has yielded much better. One year, for example, the corn from Illinois, Indiana and Ohio averaged 40 bushels per acre under the same conditions as the locally grown varieties developed near the experiment station, averaged 49 bushels per acre. Part of this difference in yield may have been due to soil differences or other things not well understood, but most of it unquestionably was due to the change in the moisture situation.

Effect of length of day.—Long hours of sunlight such as we have in late June and early July in the northern latitudes promote vegetative vigor in corn. When the day shortens, as it

does along in late summer, the plant is encouraged to put out silks and tassels. These light relationships have been proved by botanists of the United States Department of Agriculture. As to just what they mean in a practical way, no one knows so very well yet.

Well-acclimated varieties from North Dakota, which grow 6 feet tall under North Dakota conditions, will oftentimes grow only 4 feet tall in Iowa. On the best Iowa soil, with the most careful cultivation, they will oftentimes yield only 20 bushels per acre, whereas in North Dakota they yield 40 bushels. Perhaps soil differences have something to do with the situation, but it would seem that most of the variation is due to the difference in length of day during the growing season. Apparently, there are not enough hours of sunlight in Iowa during June and July to encourage the vegetative vigor which is obtained in North Dakota with the longer day.

Southern varieties of corn brought into Iowa will produce a much ranker stalk than they do when grown under their native conditions. Here again it may be that the greater number of hours of daylight in Iowa during June and July cause southern corn to grow more vigorously than the shorter number of hours of daylight in the South. This whole matter of length of day is still largely in the realm of scientific theory.

Resisting cold.—Anyone who will take the trouble to plant a hundred rows of corn, in August, each row from a different ear, will find a very interesting study when frost comes. Some of the rows will resist frost much better than others. If the first frost occurs at a temperature down only to 28°, it will be found that some of the rows will still remain fairly green, while others will be killed entirely. While no practical work has been done on this problem as yet, it is certain that there is a great difference between different strains of corn in their ability to resist cold. Holbert of the U. S. D. A. has found that some strains of corn are subject to chilling even at 46 degrees and will die as a result, while other strains will live even at 26 degrees.

At the Wisconsin station, germinating ears of corn in an

ice-box germinator has been tested and results show that some strains germinate even though the temperature is kept continuously down around 45°.

The work by Holbert, of the United States Department of Agriculture, indicates that cold resistance in corn is due to the presence of a certain chemical substance. Apparently, the day will come when strains of corn will be available which can be planted much earlier in the spring than types now used and which will also stand a light frost in the fall.

No one knows to-day to what extent the northern varieties are adapted to their northern conditions, because of smaller plant and ear, and to what extent they are adapted because they resist cold better.

Heat-resisting.—Some strains of corn undoubtedly resist high temperatures better than others. Whenever the temperature goes above 100°, corn is nearly always damaged. This is partly because such a high temperature evaporates water from the leaves more rapidly than it can be pumped from the soil. Also such temperatures nearly always come at the time when the pollen is flying, and an hour or so of such a high temperature seems to kill the pollen. Presumably, a variety which produces an unusually large amount of pollen would be to some extent heat resistant. No genuine scientific study, however, has been given to this problem of heat resistance as distinguished from drouth resistance.

Insect-resisting.—Certain strains of corn seem to resist insect attacks better than others. For example, in Illinois the Democrat or Champion White Pearl variety, which is a rather flinty white sort, resists chinch bugs much better than Reid Yellow Dent. Where there is no chinch bug infestation, the Reid Yellow Dent may yield 3 or 4 bushels more per acre than the Democrat corn, but where there is serious damage by chinch bugs, the Democrat corn may yield 10 or 12 bushels more per acre than the Reid Yellow Dent.

In the South, it is important, in selecting seed corn, to choose ears with the husk fitting tightly and coming out for some dis-

tance past the tip. Husks of this sort help the corn to resist damage by the corn-ear worm and the weevil.

It may be that certain strains of corn resist the corn-root louse better than others. This has not been demonstrated as yet, either practically or scientifically, but Gernert, formerly of the Illinois station, found a number of years ago that teosinte, a close relative of corn, was not infested with the corn-root louse on the same land where corn was seriously infested. Moreover, when he crossed teosinte with corn he found that the hybrid was free from damage by the corn-root louse. This would suggest that in all probability certain strains of corn are resistant to corn-root louse damage.

No careful work has been done as yet on developing strains of corn resistant to the European corn borer. Preliminary observations indicate that the dent varieties are more resistant than flint to European corn-borer damage because of the fact that their stalks are larger and the plants grow more vigorously. As the European corn borer becomes more widely spread in the United States, there will doubtless be a great opportunity for fundamental scientific work in developing sorts which will resist European corn-borer damage most effectively.

Buying unadapted seed corn.—Any farmer who buys seed corn, unless he buys it direct from the grower or from a seedsman who guarantees the origin, is running a great risk. The greatest risk is that he will be buying seed which was grown more than a hundred miles north or south of his farm. Another risk is that the seed may be of low germinating power.

Men on the edge of the Corn Belt are especially likely to make the mistake of buying seed corn which is not adapted to their situation. Because of unfavorable soil and climatic conditions, they may be getting yields of less than 30 bushels per acre, and therefore may think that their seed corn is running out because it doesn't look so very well. Hundreds of these men have made the mistake of buying fine-looking seed corn from the Corn Belt, only to find that when grown under their situation it would not yield as well as their native seed.

Using home-grown seed corn.—By all means rely on home-grown seed until a test on the home farm has definitely proved it to be inferior. The corn as grown by the average Corn-Belt farmer on his home farm will outyield the ordinary seed corn which he can buy by at least 5 bushels per acre. But at the same time it must be recognized that there are thousands of farmers who can find a more productive strain than they now have. It is worth while, therefore, to be always trying a peck or even a bushel of purchased seed corn and comparing it in yielding power with the home variety. In buying this seed corn for trial, however, use judgment. Buy it from someone whose corn has made a record in yielding power. Buy it from someone whose soil and climatic conditions are similar to yours. If you have to, you can afford to pay five or even ten dollars a bushel. Remember that a bushel of seed corn plants seven or eight acres and will produce on the average about three hundred bushels. A bushel of corn not adapted to your situation may easily cause you a loss of twenty or thirty dollars, whereas a bushel of really good seed corn, which is definitely better than your home variety, may give you a profit of forty or fifty dollars.

CHAPTER V

CORN SOILS AND PREPARATION OF SEED BED

The best corn soils are well-drained, deep, dark loams. Sandy soils, unless heavily manured, are not desirable for corn, as they dry out quickly and are usually low in fertility. On the other hand, clay soils are, as a rule, poorly drained and too compact to produce the best corn.

The good corn soils of central Illinois and northern Iowa contain in the plowed soil of an acre about 1200 pounds of phosphorus, 4500 pounds of nitrogen, and 35,000 pounds of potassium. On this type of soil, 1 or 2 per cent of the nitrogen and ½ to 1 per cent of the phosphorus seem to become available in the ordinary year. A 40-bushel corn crop (grain and stover) removes from the soil 60 pounds of nitrogen, 8 pounds of phosphorus and 28 pounds of potassium. Nitrogen and phosphorus are the two elements that are likely to limit corn yield. On deep peats, however, and in the eastern and southern parts of the Corn Belt, potassium is often lacking. Calcium, applied in the form of lime, often gives an increase of 3 to 4 bushels of corn per acre in the Corn Belt east of the Missouri River.

Corn is the rankest feeding and the most destructive of soil fertility of all our common crops. Only on the very richest soils can corn be grown for more than two years in succession with any assurance of profit. In humid regions, corn yields may be maintained or increased by the use of: (1) rotations, (2) barnyard manure, (3) clover, (4) crop residues, (5) good tillage, (6) commercial fertilizers.

Crop rotations.—The all-important and economical way of maintaining corn yields is to use proper crop rotations. Of

course, the short-time tenant can not make very much use of the rotation. In other cases, rotation is very valuable, and should be an important part of the fertility plan of a farm. The most common rotations in the Corn Belt (in some sections wheat is grown instead of oats) are:

1. Continuous corn.
2. Corn-oats.
3. Corn-oats-clover.
4. Corn-corn-oats-clover.

When corn is grown on good land continuously, the available fertility not only decreases rapidly, but there tends to be increasing damage from corn insects and diseases. After ten or fifteen years of continuous corn growing, the yield tends to be about 25 bushels per acre, as contrasted with 35 bushels where the corn and oats are rotated, and 65 bushels where there is a rotation of corn, corn, oats and clover, and where eight tons of manure are applied once every four years.

The corn, oats, clover rotation is preferred to the corn, corn, oats, clover rotation on the poorer soils and will give an increase of about 5 bushels of corn to the acre.

The typical, good corn soil of Iowa and central Illinois yields about 55 bushels of corn, one year with another, when a rotation of corn, corn, oats and clover is used and when eight tons of manure are applied per acre every eight or nine years. If no manure whatever is used, and reliance is placed solely on a rotation of corn, corn, oats and clover for maintaining yields, the average acre corn yield one year with another on typical good corn soil should be around 45 bushels, with the tendency very slightly downward as the lime leaches out of the soil and it becomes more difficult to get a stand of clover every four years. If a rotation of corn and oats alone is used without any clover, the yield should be around 35 bushels per acre, but with the tendency gradually downward. For ten or fifteen years there may be an average of only 5 or 6 bushels difference between the acre yield of a corn and oats rotation and that of a corn, corn, oats and clover rotation, but as the years go on, the difference seems to widen out to about 15 bushels per acre.

Barnyard manure.—If the labor spent on the corn crop is to bring in more than hired-hand wages, the yield should be more than 40 bushels per acre. But just what is the most practical plan of building up a corn soil beyond this point depends on the particular situation of each farmer. The man who has possession of a farm for only two or three years may find it decidedly inadvisable to make any effort to grow clover. But no matter how a man is situated, it almost invariably pays to haul out all

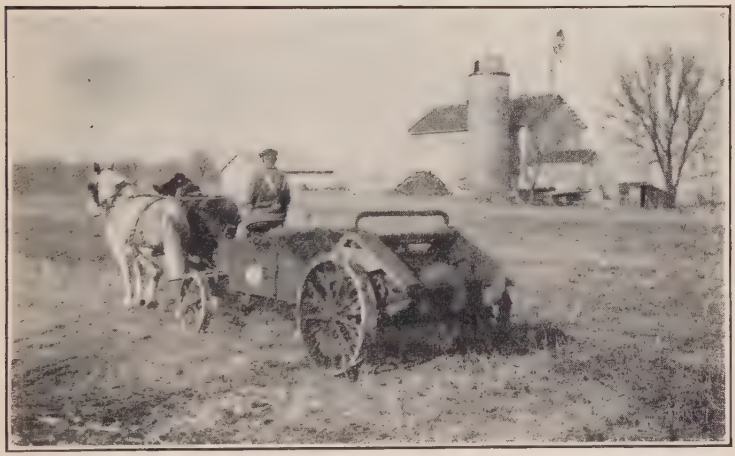


FIG. 23.—Spreading manure is one of the most important jobs connected with corn growing.

manure every spring and every fall (oftener if it is at all convenient) and spread it at the rate of about eight tons per acre on land which is to be plowed for corn. If only enough manure were available, the problem of maintaining a highly productive corn soil would be very simple. Unfortunately, on most Corn Belt farms, there is available enough manure to give an application of eight tons per acre only once in every eight years. Under practical conditions, the fields near the barn get eight tons per acre once every four years, and the outlying fields get manure rarely if ever.

A ton of manure contains about 10 pounds of nitrogen, 2 pounds of phosphorus and 10 pounds of potassium, and it normally has the ability of eventually increasing the corn yield by about 3 bushels, as well as having some effect on the small grain and clover. The first step in building up a corn soil is to haul out the manure. The man who does not do that is rarely justified in spending money for lime, phosphate or other fertilizer.

Clover.—Where a man has possession of a farm for a number of years, the third step in building up a highly productive corn soil is to grow clover once in every four years, instead of only once in every fifteen or twenty years, as is the case on most Corn Belt farms. But in order to grow clover successfully, it is necessary in many sections to apply 2 tons of limestone and 200 pounds of super phosphate (or 1000 pounds of rock phosphate) per acre once every four years. The limestone is best applied just previous to clover seeding, but the super phosphate or rock phosphate is best mixed with the manure as it is loaded just previous to being hauled out to the corn ground.

Plow under cornstalks.[1] — "Cornstalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as 4 tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil."

Proper handling.[2]—"It is a common practice in the Corn Belt to pasture the cornstalks during the winter, and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be

[1] Illinois Soil Report No. 24.

[2] Illinois Soil Report No. 24.

cloddy as a result. If tramped too long in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling, which is unfavorable to physical, chemical and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth."

Commercial fertilizers.—Having made the best utilization possible of rotations, manure, legumes and crop residues, the question arises whether mineral plant foods can be used profitably. It is well known that even livestock farming, with the most careful conservation of manure, does not maintain fertility (unless concentrates bought from outside the farm are fed). One of the most effective methods of increasing the value of manure is reinforcement with phosphorus. The use of 320 pounds of super phosphate with 8 tons of manure, at the Ohio experiment station, has increased the yields of corn 6.2 bushels; of wheat, 3.3 bushels, and of clover hay, 413 pounds.

The effects of fertilizer are not always confined to an increase in yield. Quality, maturity and composition are other important effects, concerning which, however, little is known under Corn Belt conditions. The physiological effects of small amounts of plant food, applied at various times in the growth of the plant, have yet to be studied. The effects of nitrogen, phosphorus and potassium are not so simple as are commonly supposed. At the Wisconsin station, small amounts of fertilizers applied in the hill for corn have given better results than larger amounts broadcast. The use of fertilizer in the hill is also thought to increase the salt concentration of the corn sap sufficiently to enable it to withstand a lower temperature than unfertilized corn. One hundred pounds of super phosphate per

acre in the nill at time of planting the corn has given good results in Missouri.

On peat soils 50 to 100 pounds per acre of muriate of potash may make the entire difference between success and failure of the corn crop. On most other soils potash rarely pays with corn.

Such nitrogenous fertilizers as nitrate of soda, dried blood, etc., increase corn yields but usually cost more than the value of the increase. Clover grown in the rotation will ordinarily furnish the necessary nitrogen for corn at less than one-fifth the cost of nitrogen in nitrate of soda.

Complete commercial fertilizers, such as the 2-12-2 (2 per cent nitrogen, 12 per cent phosphoric acid, and 2 per cent potash) ordinarily do not give much better results with corn than superphosphate. In a large number of Iowa experiments, 270 pounds of such a fertilizer was much more expensive and no more valuable than 200 pounds of super phosphate. Generally speaking, super phosphate, at the rate of 150 to 200 pounds per acre, is the best commercial fertilizer with which to experiment.

Preparation of the Seed Bed

In preparing land for corn planting, the big objects are to make it easy to kill weeds and to make it possible to plant the corn at a uniform depth. Ideally, the seed-bed should be firm with a mellow, level surface and with the trash cut up finely and well covered. Several diskings and harrowings after plowing kill many weeds when young which otherwise would have to be killed after the corn is up, with the corn cultivator.

Corn is planted on ground which has been in corn, small grain or sod the previous year. In the Corn Belt, about 35 per cent of the corn is planted on cornstalk ground, 45 per cent on small grain stubble and 20 per cent on sod ground. Inasmuch as the methods of seed-bed preparation vary slightly, a a separate description is given for each of the three.

Preparing cornstalk ground.—The first thing is to break the stalks. Many farmers break the stalks with a railroad iron or

heavy plank or harrow and then rake and burn. Most of the best farmers, who value the future fertility of their soil, do not burn their stalks unless they are so very heavy as to interfere seriously in planting and cultivation. Farmers who do not burn their stalks, generally knock them down and cut them up at the same time by disking. Only rarely is a stalk cutter used, and in such a case stalk cutting is usually followed by disking.

Plowing is best done in early April, soon after the stalks have been put in shape so that they can be turned under easily.

FIG. 24.—Disking the cornstalks.

The most practical depth is about 5 inches. At the Illinois station, as a four-year average with corn following corn, it was found that 7-inch spring plowing yielded 62.3 bushels and 3.5-inch spring plowing 60.9 bushels. A difference of only 1.4 bushels per acre is scarcely enough to pay for plowing twice as deep. The practical conclusion of this experiment, as well as the belief of experienced farmers, is that 5-inch plowing is as good as any when corn follows corn.

Fall plowing of cornstalk land is possible only in case husking has been done unusually early or the corn has been cut for fodder

or silage. At the Illinois station, it was found as a four-year average with corn following corn that land fall-plowed 7 inches deep yielded 63.3 bushels, whereas land spring-plowed yielded 62.3 bushels. In the same experiment, land fall-plowed 13 inches deep yielded 63.6 bushels. Evidently the time and depth of plowing cornstalk land does not have any great influence on yield. The farmer who spring-plows cornstalk land 5 inches deep is evidently following sound practice.

In the case of spring plowing, each half day's plowing should be harrowed in the direction of plowing, with a spike-tooth harrow, (1) to prevent the formation of clods and loss of moisture by evaporation, and (2) to level the surface and make disking easier.

A week or so before planting, one or two diskings should be given the plowed ground. Disking at this time will kill a great many weeds which are just beginning to sprout, and will compact the lower part of the seed-bed while at the same time the upper part of the seed-bed is made loose and mellow. If only one disking and one harrowing are given just before planting, it is best to have the disking go crosswise of the plowing, and the harrowing crosswise of the disking. The final result of the disking and harrowing should be a seed-bed in which the corn can be planted in moist ground at a uniform depth of about 2 inches.

Plowing to fight European corn borer.—Experiments prove that one of the most practical ways to fight the European corn borer is to turn under all cornstalks completely. This can be done if the plow is equipped with a running coulter and jointer and three wires attached to the axle. The depth of plowing need not be more than 6 inches. The borers can find their way to the surface but they perish if there is no vegetation or rubbish on the surface.

Preparing small-grain stubble.—Small-grain stubble which is to be put into corn is best plowed in the fall, so as to make the spring work less rushing. Theoretically, fall plowing has many other advantages, such as destruction of insects and more

complete decay of the stubble and weeds turned under. Freezing and thawing during the winter mellow the exposed soil so that it takes but little labor to put it into perfect condition for corn planting. Fall plowing should not be used with land which

FIG. 25.—Good plowing.

either washes or blows badly. Practical farmers fall-plow stubble land about 6 inches deep, and there are no experiments indicating that this is not about right.

When small grain stubble is plowed in the spring, 5 inches

seems ordinarily to be the most practical depth. Following plowing, spring-plowed small-grain stubble land is harrowed, disked and harrowed in the same way as cornstalk land. A cultipacker or roller is often used to very good advantage just previous to or just following corn planting in the case of land which was in small grain the year before.

Preparing sod ground.—There are more advantages in plowing clover, timothy or blue-grass sod for corn in the fall than stubble ground. Sweet-clover sod after one year's growth is an

FIG. 26.—Harrow each half-day's plowing.

exception. It should be spring-plowed in order to keep down volunteer growth. It is advisable to plow other sods late in the fall to allow for a maximum growth of pasture or green manure. Fall-plowed sod is far easier to work than spring-plowed sod. Fall plowing of sod reduces the damage done to corn by drouth the following season. In addition, late fall plowing will destroy many cut-worms, wire-worms and other insects which are more noticeable after sod. Blue-grass sod should be plowed shallow, and clover sod deep, because of the difference in rate of decay. It is best to allow the fall-plowed ground to lie rough over the

winter, but it must be worked down early in the spring and otherwise carefully managed. If spring-plowed, sod ground should be disked first, plowed early and shallow, and then disked and harrowed thoroughly. After spring plowing of sod ground, double disking with cross disking is necessary. The amount of work required to put the ground in good shape for corn will depend on the condition of the sod and the time of breaking.

FIG. 27.—Harrowing 40 acres of corn land in a day.

Wild grass sod is harder to work than clover and timothy sod, and is much slower to decay. This kind of sod should be plowed in the early summer, if possible. Deep breaking, 4 to 6 inches, should be done, and the furrow slice should be turned over flat. Shallow plowing, 2 to 4 inches, followed by "back-setting" (second plowing) about 2 inches deeper, after the sod has rotted, is a desirable method for tough sod. In either case, the ground should be thoroughly packed and disked to put the seed bed in good condition for corn.

At the Illinois station, as a six-year average in plowing sweet clover at the end of its second year of growth, it was found that

13-inch fall plowing gave a yield of 65.7 bushels; 7-inch fall plowing, 65.0 bushels; 7-inch spring plowing, 65.9 bushels, and 3.5-inch spring plowing, 63.6 bushels. This six-year experiment would indicate that with leguminous sods fall plowing may not have quite as great an advantage as theoretical considerations would indicate.

Standard day's work.—The amount of work done in a ten-hour day on average Corn Belt farms (based on 1922 Yearbook, United States Department of Agriculture) is as follows:

Plowing with horses:

	Acres
Walking, 14-inch, one man, two horses	1.9
Sulky, 14-inch, one man, four horses	2.6
Gang, 24-inch, one man, four horses	4.1
Gang, 24-inch, one man, six horses	4.9

Plowing with tractor:

Two-plow	6.7
Three-plow	8.2
Four-plow	10.4

Harrowing with horses:

Sixteen-foot spike-tooth, one man, four horses	38.7

Disking with horses:

Eight-foot single disk, well-packed land, one man, four horses	17.1
Eight-foot single disk, freshly plowed land, one man, four horses	15.2

CHAPTER VI

PLANTING CORN

The three common methods of planting corn are: (1) surface planting, (2) listing, and (3) furrow opening. From the information in the following paragraphs the grower should select the method that he should use. In general, surface planting is used over the greater part of the Corn Belt and because of the weed situation, most surface planted corn is checked or planted in hills so as to permit cross-cultivation. Listing is done in dry, windy regions and on light soils. Furrow opening is a modified type of listing.

Corn Planters

Types of check row planters.—Three common types of check row corn planters, on the basis of the planter plate used, are: (1) edge-drop cumulative, (2) flat-drop cumulative, and (3) full-hill drop. The edge drop seems to be the least foolproof of any, but farmers who take great pride in carefully grading seed corn of the Reid Yellow Dent type, often think that they can get more accurate results with an edge-drop planter than with any other sort. Actual experiments indicate, however, that there is no great difference between the edge drop and flat drop and that with rather thick, shallow kernels the flat drop may have a considerable advantage over the edge drop. In tests run by C. L. Reed, of the University of Illinois, it was found that with graded Reid Yellow Dent seed corn, the flat-drop planter gave 88 hills out of 100 with three kernels, whereas the edge drop, with the same seed, had 86 hills, and the

hill drop, 67. With graded corn of the Champion White Pearl, with its thick, shallow kernels, the percentage of accuracy in the case of the flat drop was 86, and the edge drop 69. With both the edge drop and the flat drop, it is especially important to have the right size of planter plate. In this Illinois experiment, for example, the same seed which was planted with 88

Fig. 28.—Planting corn.

per cent accuracy with the best-adapted flat-drop plate, was planted with only 21 per cent accuracy with the next size smaller flat-drop plate, and in the case of this small plate, over 37 per cent of the hills were twos, 29 per cent ones, and 9 per cent blanks. Moreover, 8 per cent of the hills contained broken kernels when the small plate was used, while when the right size of plate was used, only one hill out of every 200 con-

tained a broken kernel. Apparently, a plate too large does not cause quite so much damage as a plate too small, for in this Illinois experiment, this same graded Reid corn when run through a flat-drop plate one size too large, was all right except that 11 per cent of the hills were fours, as compared with only 3 per cent with the right size of plate. Moreover, there were broken kernels in 3 per cent of the hills, or about six times as many broken kernels as with the right size of plate.

The hill-drop type of planter seems to be decidedly more fool-proof than either the edge cumulative or flat cumulative. Just as good yields can be obtained with the hill drop and more than 70 per cent of the farmers use the hill drop. It seems that the typical hill-drop planter will plant about 70 per cent threes, 20 per cent fours, 3 per cent fives, and 7 per cent twos. Theoretically, the accuracy is less than with either the edge-drop or flat-drop cumulative, but from a yield standpoint there is no difference in the final results obtained. At the Nebraska station, as a five-year average, it was found that alternating hills of one, two, three, four and five plants yielded at the rate of 58.6 bushels per acre, as compared with 59 bushels where every hill contained three plants. It would seem, therefore, that the so-called inaccuracy of the hill-drop planter would have no effect on yields. The hill-drop planter will handle ungraded or odd-shaped corn more accurately than either of the other types.

Calibrating the planter.—With any planter, and especially with the edge- and flat-drop cumulatives, it is important to get the right size of planter plate. This testing, or calibrating, is best done by cleaning off a space on the barn floor and blocking up the planter so that one wheel is free to turn and both wheels are level and the furrow openers have the same position as when planting. There should be room so that the hand can be slipped under the furrow opener to catch the corn as it is dropped while the wheel is being turned at about the same rate as though it were traveling about two and one-half miles an hour. It takes two people to do the work right, and one should keep a record of the number of kernels dropped hill by hill for

about 200 drops. If three kernels are desired per hill, the plate should be changed until at least 70 per cent of the hills have three kernels and no more than 3 per cent of the hills have less than three. With a flat-drop or edge-drop cumulative, it is best to keep changing plates until the accuracy of dropping is at least 80 per cent. In some cases it may be necessary to file a plate which is just the least bit too small. As a rule, it is best to have a plate just a little large rather than a little small. The planter plate adjusted to each lot of corn should be put with that particular lot in order to avoid any confusion at planting time.

Corn Planting Methods

Method of checking.—Checking corn so that the rows are straight in both directions is a fine art. As a rule, the planter should be driven back and forth the long way of the field and the work should begin on the straight side. The end of the reeled wire is fastened to the iron stake, which is driven into the ground in the corner of the field where the work is being started. Then the planter carrying the spool of wire is driven to the other side of the field, unreeling the wire. After laying the wire across the field, it should be stretched reasonably tight and fastened to the other iron stake. The wire is then connected with the planter and the first two rows are planted with one trip across the field. At the end of the field, after these first two rows are planted, the wire is released and the planter turned around and the wire is moved over twice the distance between the rows. In moving the stake with the planter wire attached, it seems to be best to set the stake in the ground about 16 feet back of the planter and in line with the tongue of the planter. The planter wire should be pulled just medium tight, or, as one practical farmer puts it, "it should be pulled just tight enough so that there will be about seven buttons between the planter fork and where the wire touches the ground." In order to get even cross-checking, it is especially important that the wire should be pulled to the same degree of tightness at both ends.

After the first few rounds with the corn planter, it is well to dig up a few hills in different rows to see how they are cross-checking. If they are considerably out of line, it is because the corn is being dropped ahead of the button or behind the button. When the corn is being dropped ahead of the button or toward the team, it indicates that the furrow openers are tilted too far forward and that the difficulty can be remedied by lengthening the neckyoke straps or by making an adjustment where the tongue joins onto the planter. On the other hand, if the hills

FIG. 29.—Planting three rows of corn with a tractor.

are dropped considerably back of the button, it indicates that the furrow openers should be tilted forward by shortening the neckyoke straps or adjusting the tongue where it joins onto the planter. It is always essential of course, to drive the planter as straight as possible if the rows crosswise are to be straight. A steady moving team is essential because the speed of the team influences where the corn is being dropped relative to the knots on the wire. If the team is moving continually about two and one-half miles an hour, it is possible to adjust the planter so that it will drop just right for that speed, but if the team walks part of the time at two miles an hour and part

of the time at four miles an hour, there will be trouble in the cross-checking because of the fact that a fast-moving planter tends to drop the corn ahead of the button and a slow-moving planter behind the button.

In the case of an irregular-shaped field where the rows lengthen or shorten as the work progresses, it is best to set stakes at the irregular end, setting one every ten buttons, the series of stakes representing a cross-row. In this way the operator may keep all the cross-rows straight, setting his wire so that a certain marked button is constantly in direct line with the row of stakes. In case of surface irregularities, such as ridges or depressions, it is almost impossible to make the cross-checking perfectly straight.

Drilling.—With drilled corn the rows are customarily put about $3\frac{1}{2}$ feet apart, as with checked corn, but in the rows the kernels are customarily dropped about one every 12 or 14 inches, instead of three in a hill, $3\frac{1}{2}$ feet apart. The drilled corn can be cultivated only one way, which means that if the ground is at all weedy the corn will suffer more from weed competition. Experiments indicate that when the ground is not weedy and the same number of kernels are planted on an acre as with checked corn, the yield is fully as great as with checked corn. Ordinarily, however, the weed situation is such as to give checked corn a slight advantage over drilled corn. The ordinary corn planter can be used satisfactorily for drilling. In the northwest, grain drills with part of the holes stopped up have also been used for drilling.

Drilled corn cuts a little more easily with a corn binder than checked corn, and for that reason, when the ground is clean, both fodder corn and silage corn are often drilled. Drilling is also used occasionally on hillsides to check erosion, the drills being at right angles to the slope of the hill.

Listing

Listing is practiced in western Kansas, western Nebraska, Oklahoma and parts of northwestern Missouri and western

Iowa. Listing is based on the idea that if corn is planted in a furrow and then earth is filled in as the corn plants grow, a large root system will be encouraged because roots will be put out from the lower joints of the corn plants which are covered. Ordinary deep planting will not accomplish this purpose, but planting in a furrow followed by filling in the furrow with earth will result in an unusually large root system. When corn is planted in the bottom of a furrow, however, it does not grow quite as vigorously early in the spring because the soil is cold, and if the

FIG. 30.—The two-row lister in action.

weather is wet there is an additional handicap. The stalks of listed corn are generally slightly smaller than the stalks of surface planted corn of the same variety, planted under the same soil and climatic conditions. It seems that planting corn in the bottom of a furrow with a lister will continue to be popular only in seasons which are rather dry. Listing never seems to be practiced on shallow or poorly drained soil. The farmers of western Kansas and Nebraska think that listed corn stands drouth better and does not blow down so easily as surface planted corn. The biggest argument for listed corn, however, is that listing is cheaper and quicker than surface planting.

Listing is the process of throwing open a series of furrows across a field by means of a double moldboard plow that throws the soil both ways. In connection with this double plow is a drill attachment by means of which the corn is planted in the bottom of the furrow.

Ordinarily, Kansas and Nebraska farmers single list their corn, which means that the ground between the rows is not plowed, although there is a covering of loose earth over it which is thrown out by the lister in making furrows every $3\frac{1}{2}$ feet. With single listing, considerable labor in the way of plowing, harrowing, disking, etc., is avoided, with the result that the typical acre of western Kansas or Nebraska corn requires about three hours less man labor and ten hours less horse labor than the typical acre of Iowa or central Illinois corn.

With double listing the corn is not planted at the time of the first listing—but at the time of the second listing, which is done in between the rows of the first listing, the corn is planted. This method results in breaking up the ground much more thoroughly than single listing, but experiments do not prove that it has any particular advantage from the standpoint of yield over single listing.

Furrow opening.—A furrow opener consists of a pair of disks or shovels attached to the planter runner slightly in front of where the seed is dropped. These disks may be set at different depths, but ordinarily they throw out 3 or 4 inches of dirt and the corn is planted in the moist dirt at the bottom of this little furrow. After the corn is up, the cultivation or harrowing that is done in filling up this little furrow makes it possible oftentimes to kill weeds close around the corn more effectively than would otherwise be the case. Furrow opening seems to be the most popular in the western part of the Corn Belt in sections where listed corn does well, but where, for some reason, it is desirable to check instead of list. It will be noted from the following table that as an average of nine years, in northwestern Missouri, corn planted with furrow openers yielded about 7 bushels more per acre than corn planted in the ordinary way,

although it yielded about 5 bushels per acre less than corn planted with the lister. Furrow opening attachments for any corn planter can be bought for a few dollars, but in the central part of the Corn Belt they are used very little.

In Table XI it will be noted that in northwestern Missouri single listed corn yielded better than ordinary surface-planted corn in every one of the nine years under experiment. In warm, dry soils in warm dry seasons, listed corn has apparently had an advantage over surface-planted corn. The most practical kind of listing, from the standpoint of yield and labor-saving, is listing without disking.

TABLE XI

YIELD OF CORN AS DETERMINED BY THE METHOD OF PREPARING THE SEED BED, (MARYVILLE, NODAWAY COUNTY, MISSOURI)—1911 TO 1920

Method of Preparing Seed Bed	Yield in Bushels per Acre									Nine-year aver., bushels per acre	Av. increase over surface planting
	1911	1912	1913	1914	1915	1916	1917	1919	1920		
Ground plowed, crop surface planted	49.9	62.8	14.5	44.9	41.1	46.3	75.0	78.5	51.7	51.6	
Ground plowed, crop planted in shallow furrows	55.6	76.5	18.6	51.4	53.0	60.9	81.9	78.4	55.2	59.0	7.4
Double listed	56.9	73.0	18.2	54.6	44.3	53.8	68.4	84.4	54.7	57.6	6.0
Double disked, single listed	67.4	75.5	36.7	54.1	42.5	56.7	80.2	75.2	53.2	60.2	8.6
No disking, single listed	60.3	80.0	43.1	58.1	45.2	59.2	84.2	91.9	55.9	64.2	12.6
Average	58.0	73.5	28.2	52.6	45.2	55.3	77.9	81.7	54.1	58.5	
Inches of rainfall, June, July and August	5.71	6.30	8.78	6.28	31.1	10.8	10.7	8.78	5.28		

Farther north and east in the Corn Belt where the soil is not so warm and dry as it is in northwestern Missouri, Kansas

and Nebraska, the practice of listing is not so practicable. There is some reason to believe, however, that listing should be used somewhat more extensively in the eastern part of the Corn Belt than it has been hitherto.

Rate of planting.—Thickness of planting depends on variety, soil, latitude and purpose for which grown. Also it should be kept in mind that in the central part of the Corn Belt only 70 per cent of the kernels planted produce stalks. Most growers in the Corn Belt plan to get about three kernels in a hill, the rows being $3\frac{1}{2}$ feet apart both ways. This distance between rows is more or less standard for planters, check wires and cultivators. In drilled corn the distance between rows is the same as in checked corn, and the kernels should be dropped on the average from 10 to 14 inches apart in the row.

The most careful work on rate of planting corn in the Corn Belt has been done by the Ohio experiment station. The climate under which these Ohio experiments were conducted is quite typical of the north-central part of the Corn Belt, but the soil is decidedly better than average. The results of these Ohio experiments are shown in tabulated form.

In these Ohio experiments it is important to remember that all of the corn was planted thick and then thinned down to the required number of stalks per hill. So far as the practical farmer is concerned, it is necessary to plant about four kernels per hill in order to get three stalks per hill. Apparently on 60-bushel corn land in the northern part of the Corn Belt, it pays to plant about four kernels per hill with the idea of getting three stalks per hill. Even thicker planting may give a slightly greater yield, but in the case of the thicker planting the greater yield is composed almost exclusively of nubbins. Next to the last of these tables reveals the fact that when there are four stalks to the hill there are three times as many plants per acre bearing nubbins as when there are two stalks per hill, and about four times as many barren plants per acre as when there are two stalks to the hill. Thick planting on rich land will increase the yield if the season is favorable, but it may reduce the average

TABLE XII

Relation of Yield to Rate of Planting—Ohio Tests

Bushels of Shelled Corn per Acre—Ears and Nubbins

Stalks per hill	1	2	3	4	5
Four years of lowest yield—1910, 1907, 1923, 1912	25.35	40.31	45.77	44.23	41.22
Four years of highest yield—1905, 1909, 1917, 1921	37.67	63.35	79.24	85.68	89.93
Twenty-one year average, 1904–24	39.91	51.26	62.92	66.64	65.79

Bushels of Shelled Corn per Acre—Nubbins Only

Four years of lowest yield—1910, 1907, 1923, 1912	1.85	4.71	8.33	12.99	16.46
Four years of highest yield—1905, 1909, 1917, 1921	2.19	2.05	3.74	7.58	12.46
Twenty-one year average, 1904–24	1.91	3.25	5.66	10.46	15.82

Bushels of Shelled Corn per Acre—Sorted Ears Only

Four years of lowest yield—1910, 1907, 1923, 1912	23.50	35.62	37.44	31.24	24.76
Four years of highest yield—1905, 1909, 1917, 1921	35.48	61.30	75.70	78.10	77.47
Twenty-one year average, 1904–24	30.00	48.01	57.26	56.18	49.97

Barren Plants, Nubbin Plants and Good Plants per Acre

Plants per acre bearing good ears	3,410	5,794	7,663	8,240	7,982
Weight per ear in ounces	11.5	11.0	9.7	8.5	8.0
Plants per acre bearing nubbins	580	976	1,727	3,290	5,158
Weight per ear in ounces	4.25	4.2	4.2	4.2	4.05
Barren plants per acre	302	762	1,615	2,937	4,867
Two-eared plants per acre	737	422	340	247	232

Effect of Rate of Corn Planting on Yield of Stover and Grain per Acre

Pounds of stover per acre	2,114	3,005	3,643	4,030	4,481
Pounds of ear corn per acre	2,260	3,642	4,483	4,776	4,708
Therms of energy in ear corn	1,654	2,659	3,254	3,446	3,398
Therms of energy in stover	668	950	1,152	1,275	1,417
Total therms of energy in grain and stover	2,322	3,609	4,406	4,720	4,815

size of ear to a point where there is considerable extra labor in husking. Of course, this extra labor of husking is not a factor when the corn is planted for silage, and it would seem that, except on poor land, it would be worth while to plant silage corn at the rate of about five kernels per hill or else drop the kernels 8 inches apart in drilled rows.

Over the southern half of the Corn Belt, with the larger-stalked varieties of corn and on soil which is of average or below average fertility, it seems that practical farmers favor what is known as the two and three rate of planting. Thicker planting than this on soil of this sort results in a rather high percentage of nubbins, expecially if the year is at all dry.

The influence of small-stalked and large-stalked varieties on the most favorable rate of planting is illustrated by a three-year experiment at the Nebraska station. Hogue Yellow Dent, which has a stalk growing about 8 feet tall, was planted at the rate of three, four and five kernels per hill, and yielded at these rates as a three-year average: 56, 54, and 50 bushels per acre, respectively. Minnesota 23, a small early variety, with stalks growing about 5 feet tall, was planted during the same year at the three, four and five-kernel rates, and yielded 35, 38 and 42 bushels per acre, respectively. This would seem to indicate that when 90-day corns are planted during June it may be wise to plant five kernels per hill. Also when early corn is planted for hogging down, thick planting may be advisable.

Depth of planting.—Ohio, Indiana and Illinois experiments indicate that corn planted 1 or 2 inches deep will, on the average, yield at least three or four more bushels per acre than corn planted 3 or 4 inches deep. Shallow planting seems to be especially worth while in the case of rather wet, heavy, cold clay soils. In the case of warm, dry loams it may be worth while occasionally to plant deeper than 2 inches. If the weather has been unusually dry in April and early May, it seems to be a good plan to put the corn down to moist earth even though it is covered with more than 2 inches of soil. In most seasons, the average farmer plants his corn too deep

rather than too shallow. Many do this under the mistaken impression that deep planted corn will have a larger root system. The diagram on page 176 illustrates why this can not be true. No matter how deep corn is planted, it still sends out its permanent root system just underneath the ground. It is only by listing or furrow opening and then filling in the ground around the corn after it has come up, that it is possible to increase the root system. Deep planting has nothing whatever to do with it.

Time of planting.—Corn planting usually begins when the normal mean temperature reaches 55° F., and the bulk of planting is done when the normal mean temperature reaches 61° F., which means about the middle of May in the central part of the Corn Belt. April planting and sometimes early May planting is more difficult to keep clean than later planting, and often the stand is reduced because of cut-worms and other insect damage. About one year in seven or eight a late spring frost will seriously damage corn planted the last week in April. The typical frost kills the upper two or three leaves, but new leaves usually come on after a few days. It is really astonishing what a severe frost corn will stand and yet send up a vigorous new growth from the roots. Farmers have found by experience, however, that if a heavy frost occurs before May 20, it is often best to replant even though the frosted corn will send up a strong new growth. After May 20, it is usually best, unless the frost has been altogether extraordinary, to let the early planted corn stand.

Experiments in the central part of the Corn Belt indicate that one year with another the highest corn yields are obtained when planting is done the second week in May. Once in a long while there will be a period of cold weather during the first three weeks of May which will result in corn planted late in May yielding more than the early planted corn. One year with another, however, it seems to pay to plant corn just a little earlier than the average. Many farmers think that corn planted the last two or three days of May or the first two or three days of June yields better than it actually does. In November, at

husking time, late planted corn will usually run around 35 per cent moisture, whereas early planted corn will contain only about 25 per cent moisture. The ears of the early planted corn may look considerably smaller, however, than the ears of the late planted corn, and the yield may seem smaller unless the difference in moisture is taken into account. In soft corn years, early planted corn usually has a tremendous advantage. It is in years when the May weather is unusually cold or wet or there is a severe late spring frost, that early planted corn yields less than late planted, and in such years it is possible, in case the early planted corn is severely damaged, to replant. As a general rule, it would seem that in the central part of the Corn Belt every effort should be made to plant corn before May 18, and if the weather is unusually favorable, before May 15.

Acres planted per day.—According to the United States Department of Agriculture Year Book for 1922, the standard number of acres planted in a ten-hour day is about as follows:

Two-row planter, $3\frac{1}{2}$-foot rows one man, two horses,..	14.0 Acres
By hand, $3\frac{1}{2}$-foot rows, one man.....	4.5 "

Professor Kiesselbach, of Nebraska, estimates the standard number of acres planted with a lister in a ten-hour day as follows:

One man and four horses.....	10.0 Acres

CHAPTER VII

GROWING CROPS WITH CORN

Occasionally, other crops are grown with corn to balance the corn ration for animals and to utilize the ground better. It has not yet been fully proved that the returns warrant either reason for growing some other crop with corn. At any rate, there are many essentials and precautions to keep in mind in order to get the most out of an acre of corn and to feed the corn profitably.

The crops ordinarily planted with corn are soy beans, rape, cowpeas (in the southern Corn Belt), and sometimes pumpkins. Clover and rye have been sown in corn just before the last cultivation of the corn, with varying success. Usually the lack of moisture causes poor results and makes it a poor practice. The crop sown with corn should be well adapted to the locality and add more to the combination than it takes away.

Soy Beans

Soy beans are a comparatively new crop in America, especially in the Corn Belt. Trials during the last twenty years have shown the crop to have a wide range of adaptation, including all the corn and cotton lands of the country. The seeds are four times as rich in protein and fat as shelled corn.

The most popular use of soy beans in the Corn Belt is for planting with corn for hogging-down or for silage. Over 70 per cent of the soy beans grown in the Corn Belt are planted with corn for hogging-down. The beans are planted at the same time as the corn. They are erect-growing annuals which do not interfere with the growth of corn or with cultivation. The

cost of cultivation is not increased by the addition of the beans, and the feeding value of the corn is improved. There is no great difficulty in handling the beans with corn for silage.

FIG. 31.—Soy beans in corn furnish green feed rich in protein.

Effect on yield of corn.—When sown at the ordinary rate of three beans with three kernels of corn per hill, most experiment stations agree that there is some reduction in yield of corn. Practical farmers, however, seem to be of one opinion, that the

total feeding value of the crop is increased. The amount of the decrease in the corn yield will depend almost entirely upon the amount of moisture and plant food available for the crop. If there is sufficient of each for both crops, little decrease in the yield of corn can be noticed, but if the crop is struck by drouth, the corn will suffer before the beans.

On the average in the Corn Belt, it seems that soy beans grown at the rate of two stalks per hill reduce the yield of corn about 6 bushels per acre, and that the yield of beans per acre is about 4 bushels. Of course, there is great variation with the soil and season. As to whether the 4 bushels of soy beans are more than equal in feeding value to the 6 bushels of corn is a debatable question when the corn is hogged down. Table III, giving results of Missouri experiments, indicates that when no tankage is fed, the soy beans are decidedly worth while, but that when tankage is fed, the soy beans are not worth while. When corn and soy beans are used for silage, there is no clear-cut proof as yet that the mixture will produce any more milk or beef per acre than corn silage alone. Theoretically, there should be some advantage, but no careful feeding experiments have yet proved the point.

Method of planting.—The most practical method of planting beans with corn is to place the beans in the hills of corn at the same time the corn is planted. This is best accomplished by means of a bean attachment for the planter, which is operated by the check wire the same as the corn planter. It is also possible to drill corn and drill beans at the same time, or to check corn and drill beans between the hills. The latter method has given greater yields of both corn and beans than hills of corn and beans together, but there are disadvantages in the cultivation of such a planting. Beans and corn may be mixed and planted from the corn planter box, but this is not so satisfactory, as an uneven stand of corn often results because the beans settle to the bottom of the planter box faster than the corn. Practical farmers, by adding a handful or so of beans on top of the corn at each round, can overcome this objection to some extent.

Rate of seeding.—About three beans per hill of corn should be planted. The greater the number of beans per hill, the greater the reduction in the yield of corn.

If three beans are planted per hill, the pounds of beans required for each acre are:

	Pounds Per Acre
Manchu (large seed)	5.0
Medium green (large seed)	5.0
Ito San (medium seed)	3.5
Chestnut (medium seed)	3.5
Ebony (medium seed)	3.5
Midwest (medium to small seed)	3.0
Peking (small seed)	2.0

One bushel of beans, therefore, will plant from twelve to thirty acres, depending on the size of the beans.

Varieties.—The several hundred varieties of soy beans are as different as are varieties of corn, and much of the success in soy bean growing depends upon the choice of the proper variety. To be planted with corn, a variety must be chosen that will ripen with the variety of corn that is used as the companion crop. For silage and sheeping-down, a later variety may be used, but for hogging-down the soy bean variety should be matured when the hogs are turned in. The early varieties, like Ito San and Chestnut, ripen readily in the most northern states. The mid-season kinds, like Peking, Manchu and Medium Green, mature in the Corn Belt. Manchu is a favorite for hogging down.

Inoculation.—Inoculation is an important factor on most Corn Belt soils. The inoculation of the seed or soil is simply applying some substance that is known to carry live bacteria. On fields that have grown a successful crop of soy beans during the past three or four years, the bacteria are usually present in sufficient numbers. On other fields, they should be supplied in order to insure maximum yields. Inoculation, however, is not absolutely necessary for the production of a crop.

There are various methods of inoculation. An easy method

is to use soil from a field that has grown a successful crop of soy beans during the previous year. Dry it in a shady place and when the soil is dry enough to sieve through a piece of screen wire, spread the seed about 2 or 3 inches deep on a clean place. Make a solution of one-half cup of sugar to one quart of hot water for each bushel of beans. When the solution is cool, sprinkle it over the beans to make them sticky. Sift the soil uniformly over the moist beans. After drying a few hours, the beans are ready to plant.

In case no inoculated soil is at hand, commercial cultures may be used with good results. These cultures may be purchased from any seed house. The method of application is essentially the same as the one mentioned, except that hot water must not be used. Directions for the use of commercial cultures always accompany the package and have been found to be reliable. Care should be taken not to wet the beans to such an extent that the seed coats will swell enough to break.

Rape

Rape is closely related to cabbage, turnips and rutabagas. The seed, the root system and the smooth, large, succulent leaves resemble those of cabbage, but there is no tendency to form a head. The plant grows 2 feet tall under average conditions, and on rich, moist soil will grow 3 or more feet in height.

Rape is one of the most valuable pasture crops which can be seeded in the corn at the last cultivation, and is more valuable than soy beans in corn, if a stand can be obtained. However, because of lack of moisture, a stand of rape in corn about twice in every five years is all that may be expected. But since rape seed rarely costs more than 13 cents a pound, and the total cost of seeding will not exceed 75 cents an acre, farmers can afford to seed rape annually with the expectancy of getting stands twice out of five years. The corn and rape growth can be harvested profitably by hogging down or by pasturing with sheep in the fall. The leafy plants also tend to shade the ground suf-

ficiently to keep the land free of weeds. Rape has little effect on the yield of corn in the average year, reducing the corn yield about one-half bushel.

Method of planting.—The seed is generally scattered with a hand seeder at the rate of 3 to 5 pounds per acre, immediately preceding the last cultivation, which should be shallow. It may be sown a little later with a one-horse drill, but the delay in time of seeding and the additional labor are objections which probably more than offset the advantage of providing a more uniform distribution and covering of the seed. The success of late seedings depends largely on the rainfall during July and August.

Some growers are obtaining better results by planting 4 or 5 rape seeds in the corn hill at corn-planting time. This is easily done by mixing the rape and corn seed in the planter box.

Varieties.—There are two types of rape, the winter or biennial and the summer or annual. The biennial kind lives two years where the winters are extremely mild, as in the South and on the Pacific Coast, but in the Corn Belt the plants are killed by hard freezes in late fall, so it is necessary to make new seedings every year. The summer or annual type, which is also known as " bird-seed " rape, produces seed the first season, but the plants do not make sufficient growth to be of value for forage. The winter or biennial kind, usually known as Dwarf Essex rape, is the only one recommended for Corn Belt seeding.

Cowpeas

In the southern Corn Belt and in the South, the cowpeas make a good growth when planted with corn. The crop requires more heat than corn and is not grown to any extent north of the southern line of Iowa. Many of the things said about soy beans apply to cowpeas. However, the cowpea is a vining plant and not erect-growing like the soy bean. Cowpeas succeed on poorer soils better than soy beans. They should not be planted until the soil is thoroughly warm. Sim-

ilarly to soy beans, the crop may be sown with corn in one operation with the ordinary corn planter. Broadcasted in the corn and covered at the last cultivation, they should be sown about 1 bushel to the acre. If cowpeas have been grown in a locality for a long time, inoculation will not be necessary. The Whippoorwill, New Era and Iron are common varieties.

Pumpkins

According to the Iowa experiment station, pumpkins are often used to advantage with corn. The seed is planted in either missing hills or adjacent to every third hill. Corn planters are now available with a pumpkin seed attachment. On a fertile soil the pumpkins do not seriously interfere with the corn crop and are an added source of revenue, yielding from 2 to 3 tons per acre.

Many of the canning factories are ready to contract for this crop in the spring at a specified price, or it may be fed to the stock. Yields ordinarily vary from 2 to 3 tons per acre, depending on the severity of injury from beetles when the plants are small and an adequate moisture supply when the pumpkins are filling out.

Other Crops

Clovers, alfalfa and rye have been sown in corn just before the last cultivation of the crop, with varying success. Usually the lack of moisture causes poor results. It is not a widespread practice and is not recommended. Many other crops may be sown with corn, but usually to no advantage.

CHAPTER VIII

CULTIVATING CORN

The average Corn Belt farmer with 50 acres of corn spends 300 hours of man labor and 600 hours of horse labor cultivating corn. At the same time, his team walks about 470 miles. This takes more time than any other farm operation except corn husking. Moreover, corn cultivation conflicts to some extent with haying and oat harvest. The principle of cultivation followed by most farmers is to cultivate the crop as many times as possible before the corn gets too high to work in. But they should keep in mind the reasons for cultivating and the cheapest, easiest ways of accomplishing the desired results.

Chief Reason for Cultivating

A large number of corn cultivation experiments have been conducted throughout corn-producing states. With but few exceptions, the tests show that in the cultivation of corn, the killing of weeds is the all-important object. The Kansas, Illinois, Minnesota and Missouri stations and the United States Department of Agriculture have obtained conclusive results showing the great importance of the weed factor. Corn hoed by hand to prevent weed growth, without stirring the soil, has yielded as much as corn thoroughly cultivated. As an example of such experiments, those at the Kansas station, conducted upon a heavy silt loam, are represented by the following tabulation of the average yields of corn variously cultivated in 1914 to 1921.

TABLE XIII

METHOD OF CULTIVATION TEST SUMMARY, 1914–1921

	1914	1915			1916		1917		1919	1920	1921	Av. of 7 Yrs.
		Upland	Bottom	Fall Plowed	Spring Plowed	Not Plowed	Fall Plowed	Not Plowed				
Ordinary cultivation..	13.0	60.1	70.0	44.7	43.9	45.3	44.4	34.9	27.7	74.8	60.1	47.0
Ordinary cultivation plus one-horse cultivator, as per judgment. ...	13.3	57.3	66.7	44.5	46.5	39.0	45.4	33.5	26.1	77.5	63.9	46.7
Ordinary cultivation plus one horse cultivator every 10 days.....	11.0	52.1	65.5	42.7	46.1	41.5	44.8	34.4	24.3	76.3	64.5	45.8
No cultivation, weeds scraped...	9.2	58.6	71.4	44.0	46.8	45.0	40.6	29.4	25.7	73.8	65.7	46.6

At the Illinois station, as an average of nine years, keeping the weeds scraped off with a hoe without stirring the soil gave a yield of 48.9 bushels, as compared with 43.3 bushels for three shallow cultivations. In the years of plentiful summer rainfall, the three cultivations usually yielded somewhat better than shaving the weeds off with a hoe, but in years of low rainfall, it seemed that killing the weeds without stirring the soil gave the highest yield. In another Illinois experiment lasting for six years, it was found that, on soil which was not fertilized, the hoe-scraped corn yielded slightly more than corn cultivated with either blades or shovels. When fertilizer was added, however, the hoe-scraped corn yielded 55.6 bushels per acre, as compared with 58.1 bushels for blade cultivated corn and 59.5

bushels for shovel cultivated corn. These Illinois experiments indicate that on ordinary Corn Belt soil, cultivation is useful only in so far as it kills weeds and that in dry seasons or on soils which are the least bit low in fertility, cultivation, by preventing the corn roots from feeding on the 2 or 3 inches of rich surface soil, causes positive damage except for the weed killing. Of course, no practical farmer will ever keep the weeds down in his corn by hoe-scraping, but as a result of these experiments he will cultivate his corn only to the extent that is necessary to kill weeds most effectively without hurting

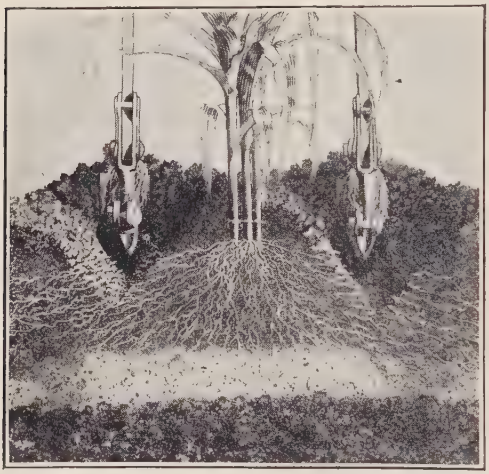


FIG. 32.—Showing how deep cultivation cuts the corn roots.

FIG. 33.—Illustrating how surface sweeps do not cut corn roots in the same way as big shovels.

the corn roots. It is only on a few very heavy soils that cultivation in addition to killing weeds is a positive benefit in letting air into the soil and thus enabling the corn to grow better as a result of the action of nitrifying bacteria. When soils crack badly during a drouth, cultivation may, by filling up the cracks, conserve some moisture which otherwise would

FIG. 34.—Rotary hoe working in small corn.

be lost. On most corn soils, however, the one object of corn cultivation is to kill weeds most effectively.

Other reasons for cultivating.—At various periods throughout the history of corn cultivation, several other beneficial results have been attributed to proper cultivation. Some of the common reasons are to:

1. Conserve moisture.
2. Make plant food more available.

3. Retard soil erosion.
4. Mix the soil constituents.
5. Improve the physical condition of the soil.
6. Germinate dormant weed seeds.
7. Give the plants a loose soil in which the roots will grow better.
8. Cover organic matter.
9. Control the soil temperature.

Under some conditions any or all of these desirable factors may be accomplished to a certain extent. But, as previously pointed out, the killing of weeds appears to be the only factor that has a great effect on the crop that year or following years. Soils lose large quantities of soil water, but this loss is due chiefly to utilization by the growing crop, transpiration from growing weeds, or internal evaporation and escape of water vapor. Only methods of tillage which will prevent loss from these sources are of value so far as the water in the soil is concerned. Excessive run off may be retarded and the absorption of water by the soil may occasionally be aided by proper methods of surface tillage.

The Right Type of Cultivator

There are a large number of corn cultivators in use to-day. Different types are of special value for different conditions and times of cultivation. However, the right cultivator should be used at the right time and under the conditions to which it is adapted. Cultivators may be divided into the following classes:

1. Shovel cultivators—(*a*) with small shovels; (*b*) with large shovels.
2. Surface cultivators—blade or sweep.
3. Disk cultivators—(*a*) surface planted corn, (*b*) listed corn.
4. Harrows—(*a*) spike-tooth, (*b*) weeders.
5. Rotary hoe.
6. Miscellaneous cultivators—(*a*) one-horse, (*b*) hand hoe.

The first three classes may be divided again according to whether they are of the one-row or two-row type. The latter are becoming common. They are of particular advantage on

large areas and for later cultivations. The two-row cultivator reduces the time required for cultivation about 45 per cent. Care must be employed when using the two-row cultivators for the first cultivation and in crossing checked corn. Another classification may be made according to whether the cultivators are horse or power drawn. At the Missouri station it required forty-two minutes to cultivate 3 inches deep an acre of 12-inch

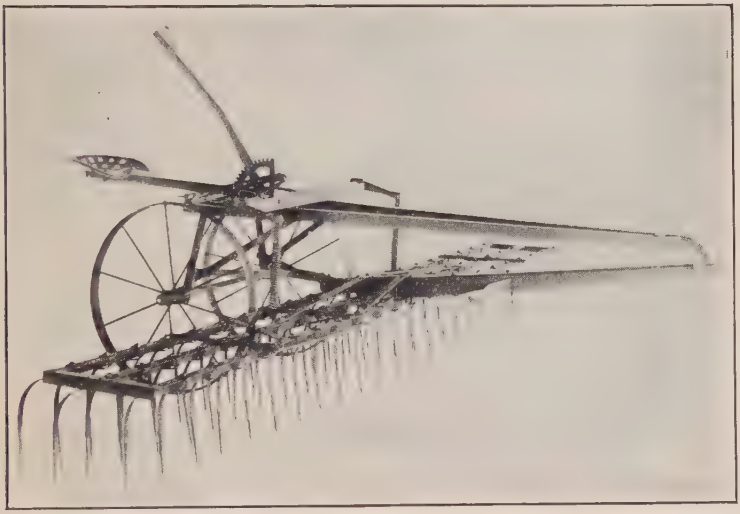


FIG. 35.—The weeder is a tool often used instead of a cultivator the first time over.

corn the third time with a two-row motor cultivator. The cultivation required three-fourths of a gallon of gasoline and one-tenth of a quart of oil for each acre. On the larger farms three-row and even four-row tractor cultivators are beginning to come into use.

The first shovel cultivators were large, and each gang of the machine carried only one shovel. These large shovels stirred the ground deeply and did considerable injury to the root system of the crop. The tendency in making shovel culti-

vators has been toward smaller shovels with more of them on each gang of the cultivator. Small shovels are desirable for the later cultivations. There are various shapes of shovels, such as the duck-foot, spearhead and the common or rectangular (sometimes called bull-tongue).

Surface cultivators are characterized by long sweeps or blades that work just under the surface of the ground. Surface cultivators are of particular advantage in the later cultivations. Many corn growers, therefore, substitute blades for shovels on their cultivators after the second cultivation. Large imple-

FIG. 36.—Two-row cultivator with duck-foot shovels.

ment concerns state that surface cultivators should be more widely used on loam soils, but that they have grown slowly in popularity because farmers have been accustomed by long usage to the shovel type. The surface cultivator has not found favor in sections of heavy clay or other tight soils. It is an excellent cultivator with which to fight morning-glories, Canada thistles and similar types of weeds.

The disk cultivator is the best type to use on weedy, grassy and sod ground. The disks will cut heavy growth that the shovels will not work in. Most cultivators used in listed corn are of the disk type.

Harrows are excellent for early cultivation. Many weeds

may be killed and a large amount of ground cultivated at a low cost with the harrow. Corn may be harrowed right after planting, before it is up, and until it is a foot high. The only time there is any danger of injury to the corn is when the field is harrowed at the time the plants are just coming through the ground. Harrowing will often take the place of one ordinary cultivation. Also, weeders cover a large amount of ground and cultivate corn efficiently, especially when the corn is small.

Another type of tool which gives much the same results as the weeder and harrow is the rotary hoe. This is splendid to destroy weeds which are just germinating while the corn is less than a foot high. The rotary hoe used at frequent intervals during late May and early June makes it possible to lay corn by with only two regular cultivations.

There may be times after the corn is " laid by "—given the last ordinary cultivation—when additional single horse cultivation is beneficial. In such case, a special type of one-horse cultivator may be used, or a mower wheel may be dragged through the field. Hand pulling or hoeing of persistent weeds after the corn is " laid by " should be practiced.

TABLE XIV

IMPLEMENTS USED IN CULTIVATING CORN (ILLINOIS STATION)

(*Bushels per Acre Produced*)

Implements	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Av.
Small shovels...	61.7	47.5	44.3	48.0	33.2	67.3	47.2	53.2	36.9	53.0	49.2
Large shovel....	61.0	45.2	42.6	45.2	29.1	62.4	47.5	57.8	37.7	54.0	48.2
Tower cultivator	64.0	42.1	43.1	51.6	33.2	67.1	50.2	53.9	38.1	49.3	49.3
Disk cultivator.	64.4	44.3	46.7	48.8	35.6	67.5	47.2	55.1	29.0	56.8	49.5

CULTIVATION PROCEDURE

The first cultivation may be made before the crop is up. While the harrow is more commonly used, some farmers prefer

to " blind plow," following the planter marks with the ordinary cultivator before the corn is up. Blind plowing is desirable in fields infested with quack grass or similar weeds. In many cases farmers neither blind plow nor harrow, but begin cultivation with the ordinary cultivator after the corn is about 4 inches high.

FIG. 37.—Two-row cultivator in action. With corn of this size it does good work with one-half as much man labor as a single row cultivator.

The first cultivation is always in the same direction as the corn is planted. Care should be taken that the young plants are not injured or covered. Either stationary or rotating shields on the cultivator will help to protect the plants from being covered by loose soil. Plants partly or entirely covered at the time of the first cultivation are permanently stunted and are either barren or produce nubbins.

The cultivator should run deeply and close to the row the

first time over, so as to cover weeds in the hills. The kernel contains food on which the plant feeds when it starts, hence the roots have not yet grown out where many of them will be disturbed. The first cultivation is the most important. If it is deep and close to the corn plants, it helps to warm the soil, destroys weeds, and loosens the ground so thoroughly that the later plowings are easier.

In checked corn the second cultivation is usually crosswise of the direction the corn is planted. The ease or difficulty of this cultivation is dependent upon how accurately the corn was checked in planting.

After the first cultivation, it is not advisable to run the shovels too deeply or too close to the hills. Allow them to throw in just enough dirt to cover weeds in the hills. A month after planting, the roots from hills, side by side, may be found to meet each other between the corn rows and to be within $2\frac{1}{2}$ inches of the top of the ground 6 inches out from the hills of corn. Plowing deeper than 3 inches close to the hills at this time tears many roots and injures the corn.

Practical farmer advice.—A farmer from Guthrie county, Iowa, describes his methods of corn cultivation as follows:

" We use the six-shovel, balance frame type of cultivator. We have tried surface plows, but found them impractical for a heavy loam soil such as ours. Always have the shovels well sharpened. We put our plows on a level floor, placing the wheels on 5 or 6 inch blocks, raise the tongue to position and do our adjusting before going to the field. This saves time when in the field, as only slight changes are necessary, and we know just what we are doing, which is almost impossible with adjusting in the field, especially if the team is restless.

" For the first cultivation, set the beams as close together as possible. The front shovels are set slightly deeper than the others to allow for deep plowing without making ' ditches ' with the rear shovels. The front shovels are turned out to throw the clods and most of the dirt away from the corn, while with the shields correctly adjusted just about the right amount

of fine dirt is rolled to the row to cover the weeds, with a minimum amount of corn covered.

"Another advantage of this is that in wet spots or hard places, no 'slugs' ever go over the shields onto the corn. The second shovels should be set straight or turned a little out, never turned in, or they are liable to cover the corn from behind the shields. The rear shovels should be turned in just enough to balance the 'pull.' A properly set beam should run straight with no pull either way. We plow as deep as possible and close to the corn the first time. The second time we plow about the same depth and a little farther from the corn, raise the shields and turn the front shovels about straight. We average from seven to nine acres a day the first two cultivations. The third time we raise the front shovels a little and turn them in, discard the shields and plow farther from the corn, to keep from cutting the roots.

"The last plowing we spread the beams as far as possible and plow very shallow. I like to lay the corn by as large as possible because this leaves a clean field with the ground well shaded. Weeds must be taken care of by the first two cultivations. Plowing deep the last two times is sure to injure the corn roots. We use spearhead shovels on one cultivator and common shovels with sweeps for the last plowing on the other. Theoretically, sweeps are best for the last cultivation, but in practice spearhead shovels are nearly as good. They throw plenty of dirt, but not too much, and cut more weeds and have lighter draft than common shovels. We find that corn yields best with four cultivations, as the field is kept cleaner and pests do not have a chance to work on it on account of the frequent stirring."

Determining the Method of Cultivation

In general, there are two methods of cultivation: (1) level cultivation, (2) hilled or ridged cultivation. Level cultivation

is best. Compared to the ridged type of cultivation it has the following advantages:

1. Less surface is exposed for evaporation.
2. Only shallow cultivation is required.
3. The field is more easily prepared for the next crop.
4. Yields are usually greater.

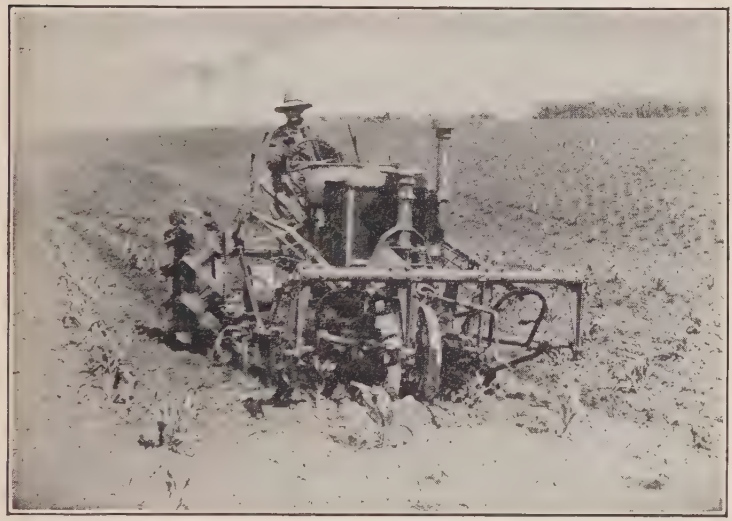


FIG. 38.—Two-row cultivator at work.

Ridging may sometimes be justified if the dirt thrown into the row covers a lot of foxtail which would otherwise get a start.

Depth of cultivation.—Occasionally cultivation four or more inches deep kills weeds more effectively than shallow cultivation, but as a rule deep cultivation is no more effective than shallow cultivation in killing weeds, and the yield is less because of the damage done to the corn roots. Moreover, deep cultivation keeps a high percentage of the rich surface soil so dry that it is not available as plant food to the corn roots. In the case of very rich soils heavily fertilized, the Illinois experiments referred to early in this chapter indicate that moderately deep

cultivation may cause no damage. In a six-year comparison between deep and shallow cultivation at the Illinois station, it was found that the shallow cultivated corn yielded more, four out of the six years, and that as an average of the six years the yields were 70.3 bushels for the corn cultivated shallow four or five times, and 66.7 bushels for the corn cultivated deep four or five times. It is common-sense practice to cultivate moderately deep the first time and rather shallow after the corn has reached a height of 1 foot or more.

FIG. 39.—Cultivating three rows of corn with a tractor.

How cultivation affects soil.—The cultivation must be suited to the kind of soil. If a field is sandy or easy to work, because it is rich in organic matter, it may be plowed from the beginning with a surface cultivator. Wet, heavy soils should be given deeper cultivation the first time to loosen them up and dry out the surface. If a shovel cultivator is used, it should not run as deeply the second time. A surface cultivator may be used on heavy soils of this type unless there have been heavy rains to pack the soil.

Number of times to cultivate.—The number of times to cultivate corn will depend upon the number and kind of weeds, the ground in which it grows and the climatic conditions. Keep the corn free from weeds, and try to keep the dirt on top loose—to hold moisture. The growth of weeds in many cornfields shows that such fields are suffering from a lack of cultivation. In others the soil is baked and moisture is lost. When the ground gets too dry after heavy rains, it will dry and crack open.

FIG. 40.—Lister two-row cultivator, illustrating method of throwing dirt away from the plants in the furrow the first time over. When the plants are larger the dirt will be thrown toward them.

These cracks allow the moisture to escape rapidly, and should be prevented by cultivation. After the corn grows tall, its foliage shades the ground from the sun, and largely prevents both the loss of moisture by evaporation and the growth of weeds. Sometimes, when the season is warm and wet, the corn may grow so fast it is cultivated only twice. The usual number of cultivations in the Corn Belt is three.

Cultivation of listed corn.—Disk cultivators are commonly used to cultivate listed corn. The disks are set to cut and throw

out the weedy fringe the first time over. A hooded shield is used to protect the plants, especially the first time over. Small shovels are set to mulch the soil in the furrow close to the corn, and large shovels are set to destroy weeds on top of the ridge. The second time over, the corn is a few inches high, and so the disks are set to throw in, filling the furrow. The shovels are set to destroy and work down the ridge. The disk cultivator is used two or three times, depending on conditions. Often listed corn is "laid by" with an ordinary shovel cultivator. Both single-row and two-row lister corn cultivators are used.

Ways of reducing cost of cultivation.—Harrow and disk the field thoroughly before planting, to kill weed growth in its early stages and to make the seed bed firm. If most of the weeds are killed before the crop is planted, later cultivations may be reduced to a minimum. Good preparation of the seed bed will lessen the cost of cultivation. The use of the harrow or weeder for early cultivation is one of the most important labor-saving practices. Two-row cultivators save man labor. Remember that the one big object of cultivation is to kill weeds.

Acres cultivated per day.—Under Corn Belt conditions, the average number of acres cultivated in a ten-hour day is about as follows:

One-row riding (first or second cultivation), one man, two horses	5.5
One-row riding (third cultivation), one man, two horses	7.0
Two-row riding, one man, three or four horses	13.0

A Kansas farmer reports that with a two-row lister cultivator of the type illustrated in this chapter, sixteen acres can be cultivated in a ten-hour day.

Weeds—Prevalence and Methods of Control

As the killing of weeds is the chief task in cultivation, the grower should be able to identify the weeds of his cornfield and to know the most feasible method of controlling them. Good corn growing is a constant battle against weeds, and the

weed factor is a large one in determining the number of acres of corn to grow. Weeds deprive corn of both moisture and plant food.

Although weeds are one of the worst enemies of corn the cornfield is an excellent place to eradicate weeds that have become a pest in meadows, pastures and small grain. In sections where corn or other cultivated crops can not be profitably grown, the weed problem is a difficult one. To rid their fields of weeds, the farmers must summer fallow, thereby losing the crop for one year. Corn growing is partially replacing summer fallow in many sections, because clean cultivation of corn frees the ground of weeds and the small western corn is not a heavy user of moisture. The spring-seeded grain crop following corn does nearly as well as after summer fallow, thus showing the importance of killing weeds.

Fig. 41.—Poor cultivation in June gave foxtail and barnyard grass such a start that the yield of this field was reduced twenty bushels per acre.

Influence of weeds on yield.*—The most important factor in the growth of a crop of corn on fertile soil with a well-prepared seed bed in humid regions is the killing of weeds. With the same preparation of seed bed, corn produced, as an eight-year average, 7.3 bushels per acre where the weeds were allowed to grow, and 45.9 bushels where the weeds were kept down with-

* Illinois Bulletin No. 181.

out any cultivation. This gives an increase of 38.6 bushels, or say $19.30 per acre, for keeping weeds down. Weeds deprive the plant of moisture, light and food, all of which are absolutely necessary for the production of crops.

The classes of weeds.—Some weeds produce enormous quantities of seeds, some produce strong underground stems (quack grass) or roots (Canada thistle), that produce new plants, and others produce both seed plentifully and strong underground systems. The weeds of corn may be classified according to the length of their life as follows:

1. Annuals—those that live one year, such as foxtail and crab-grass.
2. Biennials—those that live two years, such as bull thistle and wild carrot.
3. Perennials—those that live more than two years, such as Canada thistle and quack grass.

The annuals and biennials are usually easy to kill by cultivation, because they grow only from seed. If new weed seeds are kept off the farm, and the weeds already growing are prevented from going to seed, no great amount of trouble will be had from these. Most of the perennial weeds are propagated by underground parts as well as seeds, and the job of eradication is more difficult. To eradicate these weeds, all top growth must be kept down, so that the underground parts will starve. Care must be taken in cultivation so that underground parts are not spread by the cultivator, for small pieces take root and form new patches of the perennial weed.

Use of smother crops to kill weeds.—There are many smother crops that will control weed growth or at least weaken the growth of the weeds so that the pests may easily be eradicated by proper cultivation. Alfalfa, Sudan grass, buckwheat and sorghum are good weed exterminator crops. A heavy seeding of oats acts as a smother crop. For smother crops to be effective, the seed bed must be clean at time of sowing. Fall plowing and thorough cultivation with the disk in the spring, followed by shallow plowing before seeding, check the weeds

severely. The oats should be cut early for hay, before the weeds mature seed. After the removal of the crop, the ground should be disked and plowed.

Common cornfield weeds.—Some of the worst cornfield weeds from the standpoint of number, difficulty in eradication or damage to the corn crop, are:

Perennials

1. Canada thistle. *Cirsium arvense.*
2. Quack grass. *Agropyron repens.* (Northern Corn Belt).
3. Wild morning-glory (Bindweed). *Convolvulus sepium.*

Annuals

1. Black bindweed (Wild buckwheat). *Polygonum convolvulus.* (Northern Corn Belt.)
2. Cocklebur. *Xanthium canadense.*
3. Indian mallow (Butter-print or velvet weed). *Abutilon theophrasti.*
4. Pennsylvania smartweed (Heart's-ease). *Polygonum pennsylvanicum.*
5. Lady's thumb. *Polygonum persicaria.*
6. Foxtail (green and yellow). *Setaria viridis and Setaria glauca.*
7. Crab grass (Finger grass). *Digitaria sanguinalis.*

There are many other weeds often found in the cornfield, such as European bindweed, which is one of the worst of all when it gets in a field, milkweed, horse-nettle, shoofly, lamb's quarter, wild sunflower, barnyard grass, artichoke, ragweed, pigweed and Russian thistle (only in western part of Corn Belt).

Methods of control.—These weeds of corn are classified in four groups, as follows:

1. Weeds which require a special type of shovel on the corn cultivator.
2. Weeds which can not be handled to the best advantage unless the land is put into meadow or pasture for a time.
3. Weeds which require a thorough hand hoeing during late July or early August.
4. Weeds which are common in every cornfield but require no attention other than the ordinary three or four cultivations.

First group.—The first group includes weeds like the Canada thistle, wild morning-glory, and European bindweed and other weeds that grow from underground running roots and from seed. These running roots branch and grow horizontally from the main root. They may be found from a few inches to a few feet below the surface of the soil. At almost any time during the growing season, buds will form on these horizontal roots and send up new plants. The above-ground growth manufactures the food material that is stored in the roots. In order to starve out the plants, it is necessary to keep down all top growth. If the underground growth is not replenished by food which is made only by the aid of green leaves, all of the food in the underground roots will be used by the growing plant. In time, the plant and roots will die. It is necessary to watch for the introduction of new plants from seed.

FIG. 42.—Canada thistle.

Frequent cultivating with spearhead, surface, or duck-foot shovels is necessary so as to keep down the top growth of the weeds in this group. After cultivation is discontinued, the patches of these weeds should be kept down by hoeing. Localized patches where there is a thick stand may be summer fallowed and a crop grown on the remainder of the field. Where thistles are not too firmly established, smother crops, such as alfalfa, grasses, millet and small grains thickly sown and grown

for one season give these weeds a setback which makes easier the eradication by clean cultivation in the cornfield the following year. The plants are easily spread by root-stocks that hang on the cultivator shovels.

Second group.—In the second group are weeds such as quack grass and Johnson grass which spread by underground stems in the same way as the first group. It seems necessary to put a field that is badly infested with these weeds into meadow or pasture for a term of years. The pasturing or continued cutting of these grasses brings the underground stems closer to the surface of the ground. Exposing the underground stems by plowing will kill many of the plants. The following crop of corn will afford a good place for thorough cultivation and liberal use of the hoe. This method of control may also be used for the first group.

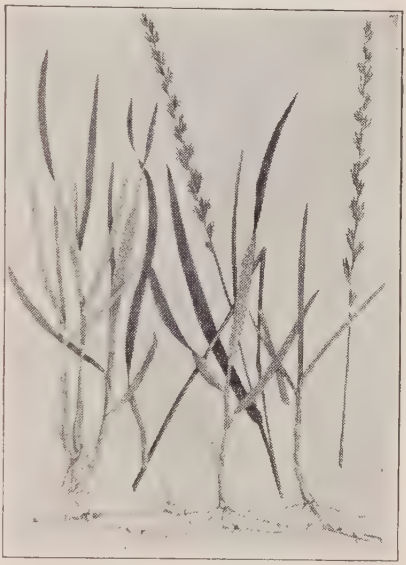


FIG. 43.—Quack grass, a bad cornfield weed in the extreme northern part of the Corn Belt.

Third group.—Persistent annual weeds, such as the cockle-bur, butter-print, black bindweed, and the Russian thistle are weeds that should be handled by the third method. Ordinary cultivation will not kill all of these weeds in a cornfield where they have a good hold. It will require thorough cultivation plus hoeing and hand pulling during late July and August to clean a field. Weeds of this type set an abundance of seed, and so every plant should be eradicated. Plants of the cocklebur a few inches high will mature seed. The bur of this weed encloses

a pair of seeds, one of which will germinate one season and the other the next season. The seed of the butter-print lives in the soil for ten or more years.

Fig. 44.—Foxtail, the most widespread annual weed in corn.

Fourth group.—Most of the ordinary annual cornfield weeds are in this class. The most common weeds of this group are the Pennsylvania smartweed, lady's thumb, foxtail, shoofly, crab grass, lamb's quarter, and pigweed. Thorough preparation of seed bed and cultivation as outlined above will rid badly infested fields of these weeds. Heavy June rains which delay the first or second cultivation permit annual weeds of this type to become very serious. In this case, the only practical thing which can be done is to cultivate as quickly and cleanly as the weather will permit. Heavy late summer rains often cause a rank growth of these weeds in August, even though the field was clean at the time of "laying by." Such a growth is not serious, and there is nothing practical to do about it.

CHAPTER IX

CONTROLLING INSECTS AND DISEASES

INSECTS OF CORN

Insects that attack corn are numerous, but most of them do not cause serious damage. Occasionally local attacks are severe and the entire crop of a community will be destroyed as a result of the work of a particular insect. Control measures, to be practical, should be simple, cheap and easily applied.

Most common corn insects have four stages in their life history, which may last a part of a year, one year or several years. The four stages are the egg, larva, pupa and adult stage. An adult insect usually deposits several hundred eggs and its function in life is completed. The eggs, as a rule, hatch out quickly into the larval or worm stage. After the worm finishes feeding, it turns into the pupal or resting stage. From the pupa emerges the adult as the butterfly does from the cocoon. Some insects such as the aphis bear live young.

The description of the insect, its life history, the character of damage done and the control measures are given of the important insects of corn in the Corn Belt. The insects are divided into five classes, those that work primarily on: (1) the roots, (2) stalks, (3) leaves, (4) entire plant, (5) stored grain.

Insects that Work on the Roots

Wire-worm.—The common wire-worms are reddish-brown in color, hard and rather shiny in appearance, cylindrical in shape and an inch or more in length. The adults are boat-shaped fellows, one-half to three-fourths of an inch long and brown or

black in color. They are known as " click beetles " or " snapping beetles," from the snapping noise they make when on their backs.

The wire-worm changes to the pupal stage in July or early August. Only two or three weeks are spent in this stage before changing to the beetle. The beetle, however, spends the winter in the pupal cell and comes out the next spring. It deposits its eggs in the soil. The larvae hatch out in a few days and begin feeding. The corn wire-worm may spend as long a time as five years in the soil, while the wheat wire-worm spends only three.

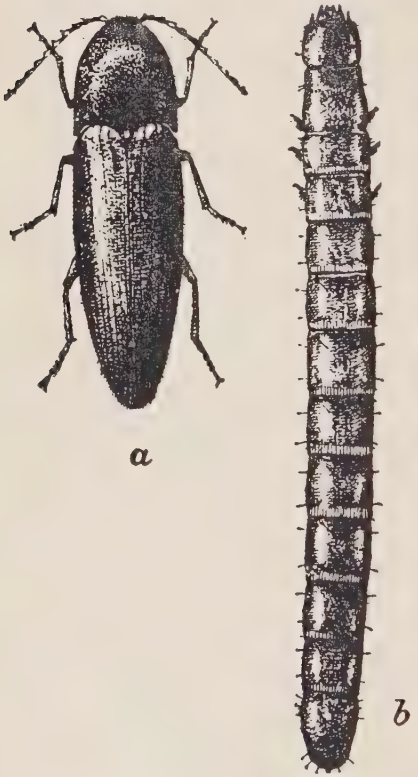


FIG. 45.—(*a*) Wire-worm beetle or click beetle. (*b*) Wire-worm (*much enlarged*). The full-grown wire-worm is only about $1\frac{1}{2}$ in. long.

The failure of seed to sprout or the withering of corn plants at 2 feet or less in height often indicate wire-worm attack. Wire-worms feed first on the seed itself, later on the roots. If the affected field has been in grass a year or so previous, the injury is most likely to be that of wire-worms. The larvae do not cause any visible injury to grass. However, when grass land is put into corn, the wire-worms concentrate upon the hills of the planted grain and cause much damage.

Wire-worms are difficult to control because (1) they work underground; (2) they cling to life; (3) there are several injurious specimens of wire-worms requiring different methods of control.

There are many useless or impracticable control measures often recommended. They are: (1) coating the seed with various poisons or repellents, such as tar, kerosene, Paris green and strychnine—an Iowa county agent says the insects enjoy and eat the protected kernels more readily; (2) treating the soil with salt; and (3) plowing late in the fall. There seems to be no practical way of controlling wire-worms aside from substituting clover for timothy in the rotation and leaving the land in clover only a year or two.

Corn root aphis.—The corn root aphis or root louse is a tiny blue-green adult. The root lice which hatch from the eggs in the spring are all the same sex, females, which produce during the summer ten to twenty generations of live young. These females are found throughout the spring and summer and the males do not appear until the fall. The root lice multiply very rapidly and cause much damage to growing plants. Most of them are wingless, but occasionally winged forms are found. In the fall, both males and females appear. Mating takes place and the females deposit eggs, instead of producing young. These eggs are taken up by the little brown ants, which care for them in their nests during the winter. The root lice are very well cared for by the ants, because the aphis secretes a sweet substance, "honey-dew," of which the ants are fond.

The presence of the corn root aphis in a field of growing corn is usually shown by (1) a dwarfing of the plants and a yellowing or reddening of the leaves; (2) finding numerous ant hills near affected stalks; (3) the presence of many lice on the main roots. The tiny lice suck the juices from the roots, thereby weakening the growth and reducing the yield.

Crop rotation is the most effective measure against the root aphis, although it feeds on other plants than corn. Where crop rotation with only one or two consecutive crops of corn is prac-

ticed, little injury occurs. The other crops grown are not much affected, as corn is the favorite food of the corn aphis. If it is not practical to rotate, deep and frequent cultivation early in the season may help.

Seed treatment methods have not proved practical.

Corn root worm.—The root worms are small, slender, white grubs, about half an inch long when full grown. The northern form of the root worm in its adult stage is a plain grass-green beetle, about one-fifth of an inch long. The beetle of the southern root worm is green, with twelve black spots on its back. It is also somewhat larger than the plain green beetle, measuring nearly a quarter of an inch long.

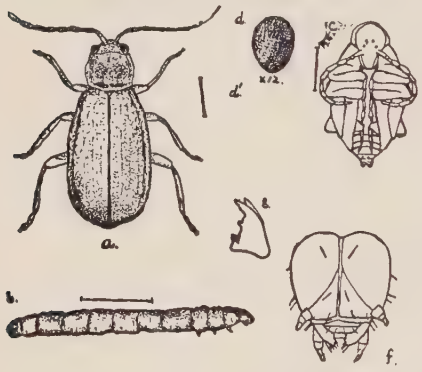


Fig. 46.—(*a*) Corn root worm beetle is grass green in color and is found in late July and August, feeding on corn tassels and corn silk. (*b*) Corn root worm burrows into corn roots, causing corn to blow down easily in summer. (*Enlarged.*)

In the fall, the beetle of the northern form may be seen on the silk of corn and the flowers of the golden rod. The beetles deposit their eggs in the soil near the stalks of corn. The next spring these eggs hatch out early. The young root worms begin to attack the corn almost as soon as it is out of the ground. Throughout the summer, the larvae work on the roots. When the larvae mature, they change to the pupal stage, in which they spend only a short time. The plain green beetle emerges from this pupa and the life history is repeated. The black-spotted beetles of the southern corn root worm are found not only in the fall, but all through the season, from early spring onward. There seem to be at least two generations of them during the year. The life history of the southern corn root

worm is similar to that of the northern form, except that it is passed through in a much shorter time.

Corn is the only food plant of the northern root worm. On the other hand, the southern root worms have been found in wheat, rye, millet and other grasses. The northern form does more injury to the corn in the north. The withering of young plants and the blowing over of the stalks may be due to the root worm. However, more often these conditions are due to other factors.

If the plain green or the black-spotted beetles are seen in very large numbers feeding on the silks of the corn in August, it is an indication that a cornfield on the same piece of ground will be infested with the root worms the next year. Those fields should be planted to some other crop than corn, and the corn put on a new field. Rotation is an almost infallible cure for the northern corn root worm, but is not such a certain preventive of the southern form.

White grub worm.—The grub is a large white insect with a reddish-brown head. It is similar to the grub found in manure piles, although the latter is not injurious to corn. The parent form of the white grub is the common May beetle or June bug, the large, black or brownish beetle which flies to the lights in May and early June.

FIG. 47. — (*a*) June bug. (*e*) Full-grown white grub ready to pupate. (*d*) Half-grown grub at stage when it does the most damage to corn. (*Reduced.*)

The beetles hide in the grass all day and after sundown feed on the leaves of trees, often doing considerable damage. They deposit their eggs in rather compact soil, usually sod ground, during June. These eggs hatch and the young grubs begin to feed upon the roots of the grass that summer. Grubs do not become full grown for two years, and even then they remain in the soil for a third winter, emerging as beetles nearly three

years after the eggs were deposited. A generalized life history is as follows:

First year—In May the beetles emerge from the soil, feed, and deposit eggs. Larvae hatch, begin to feed, and winter over in the soil.

Second year—Larvae feed during the season. The most damage to crops is caused this year. The larvae winter over in the soil practically full grown.

Third year—Larvae feed early in the season, pupate in June or July, and change to beetles a few weeks later. The beetles stay in the soil over winter.

Fourth year—Same as the first. Beetles emerge in May and early June.

The presence of the white grub is indicated by (1) dwarfing of the plant, (2) killing of the plant in any stage of growth, (3) weak root system, (4) falling of the stalk. The grubs are not known to infest such crops as clover, alfalfa or buckwheat; these may safely follow sod in a " grub year." Small grains are attacked by the grubs, but to a less extent than corn or potatoes.

Under certain conditions, grubs may be controlled by an intelligent rotation, particularly in a district known to be badly infested. Grubs are usually abundant near wooded areas. When grubs are expected in any particular year, corn should not follow sod. It may safely follow a cultivated crop. By referring to the generalized life cycle, one may determine when to expect damage by grubs. For instance, if the beetles are exceptionally abundant one year, a large number of grubs may be expected the next year. In any given locality, the grubs are likely to be numerous at three-year intervals. For example, northeastern Iowa has had outbreaks in 1912, 1915, 1918, 1921, 1924, and 1927. If the two-year-old grubs are damaging corn, there is no practical measure to get rid of them at once without injuring the crop. However, such measures as fall plowing, rotation and turning hogs in on grub-infested land may partially prevent further injury. Hogs turned into infested fields by the middle of October, before the grubs go deep, will rapidly clear out most of the grubs. The only objection to turning in hogs is that

occasionally they become infested with the thorn-headed worm, which is a parasite of both hogs and white grubs. Because the grubs go deeper into the soil for the winter, early fall plowing is of some value, as it brings the grubs to the surface and crushes many of them.

Insects that Work on the Stalks

Cut-worm.—Full-grown cut-worms are about one and one-half inches long, usually dull in color. Rarely, as with the variegated cut-worm which attacks clover, are they well marked or striped. Late in June or early in July the mature larva forms a loose cell in the soil, changes to the pupal stage, and a few days later to the adult or moth. Moths of the various species are much alike. All are dull in appearance and brown in color, with the hind wings lighter than the fore wings.

The moths deposit eggs in the grass lands late in the season. The larvae hatch the same fall and spend the winter in the soil, partly grown. Consequently, they are of good size by the time the young corn plants are pushing their way through the ground. There is usually only one generation each year.

The cutting off of the stalk at the base of the plant, at or just below the surface of the soil, is the work of cut-worms. Usually, the insect responsible for the damage may be found in the soil near the plant attacked.

If cut-worms are present in a cornfield, the only two measures to be taken are replanting and poisoning. Replanting should be delayed until damage by the insects has practically ceased. Although the cut-worm pupates in late June, it usually does very little severe damage after warm weather comes on in early June. A poison bait may be made by mixing 1 pound of Paris green with 25 pounds of dry bran or middlings. Scattered over a cornfield, this bait attracts the cut-worms, which feed on it and are killed. Results are sometimes very good, but occasionally this method seems to be worthless.

Early fall plowing of grass land to be planted in corn the

next year is a preventive measure. This plowing buries the eggs or young larvae so they can not live over winter. Close fall pasturing of such land is also a benefit. Corn land should be disked and harrowed as much as possible before planting.

Chinch bug.—The adult form of the chinch bug is about one-fifth of an inch long, black in color, with the under wings whitish. These wings cross on the back of the insect, forming a sort of an X-shaped mark. Young chinch bugs are pale yellow at first, becoming quite reddish later. At first, there are no traces of wings, but in the later stages wing pads appear. Chinch bugs shed their skins four times and after the fourth moult become full grown.

FIG. 48.—Adult winged forms of chinch bug. The larval form, which invades corn fields, looks like this, but has no wings.

During the winter, chinch bugs hibernate in clumps of grass and along fences and hedge rows. In April they go to the wheat fields, which offer plenty of food at this time. They soon deposit their eggs and their young feed on the wheat. At wheat harvest, the bugs of the preceding year are dead and the young ones have not developed wings. The bugs seek green food, and since they are unable to fly, they crawl from one field to another. Growing corn at this time is especially tempting to the partly grown chinch bugs, and the object of the control measures is to keep the bugs out of the corn. Chinch bugs mature in the corn field in July and deposit eggs for a second generation. They grow rapidly and feed on the corn. In September, the second generation matures and spends the winter as adults.

Since 1900 most chinch-bug damage has been to corn south of the southern Iowa line. Back in 1887, however, chinch-bug injury was noticeable in three-fourths of the counties of Iowa. Damage to corn occurs, for the most part, in mid-summer, when the growing bugs pass from ripening wheat to corn. It does not necessarily follow that the chinch bug will not become dangerous in localities where no wheat is grown, although that usually is the case. Chinch bugs drive their beaks into the plant tissue and suck the juices.

In general, the four control methods for the chinch bug are: (1) cleaning all rubbish and waste places, (2) barriers around fields, (3) spraying, and (4) natural enemies.

Since the chinch bugs hibernate in clumps of wild grass and similar places, much benefit may be obtained by burning rubbish along fences and hedge rows, in the winter. Clean culture does away with hibernating places in a field.

As wheat harvest in an infested field draws near, measures to prevent the insects from entering the cornfield should be taken. This is best done by making barrier lines of some repellent, such as road oil or creosote, around the infested field. The road oil barrier must be kept so sticky that the chinch bugs can not cross it, but the creosote acts on account of its repellent odor. The strip of oil should be half an inch thick or more. Post holes about 2 feet deep should be dug at intervals of about 20 feet, along the oil line. A little kerosene poured into these holes will kill the bugs that collect. These barriers must be kept freshened.

Calcium cyanide was extensively used as a chinch bug barrier for the first time in 1923. It seems to be quite satisfactory, but rather expensive. Further information can be obtained from the Illinois station, at Urbana, and the Missouri station, at Columbia.

Once the bugs are in a cornfield, spraying with tobacco extract or kerosene emulsion is the only measure available. This is usually impracticable.

The natural insect enemies of the chinch bug are not numer-

ous, nor do they thrive in hot, dry weather. On the other hand, chinch bugs are the more numerous and thrive best under these conditions. However, the natural enemies have done much to reduce the number and extent of chinch bug attacks.

In southern Illinois chinch-bug damage has been reduced by growing varieties of corn with unusually large, sturdy stalks, wide leaves, and more than usually vigorous roots. The Democrat or Champion White Pearl is probably the best of these varieties. Under conditions of moderately severe chinch-bug infestation, the Democrat will yield twice as much as Reid Yellow Dent, whereas, on the same soil, without chinch bugs, the Reid corn will usually yield two or three bushels more per acre.

Corn bill-bug.—There are several kinds of bill-bugs. Most of them are black or brown in color. All are beetles with hard backs and long snouts, which make the holes in the leaf blades. In the grub stage, the corn bill-bugs feed on the roots of certain grasses. One of the most common species feeds on timothy roots.

In general, the insects spend the winter in the beetle stage and work in this stage upon the young corn plants in the late spring. In the early summer, the beetles deposit their eggs on timothy and other grasses. The eggs hatch and the young grubs feed on the grass roots until early fall, when the adult beetles appear. Before changing to beetles the grubs enter the pupal stage for a short period.

The tender leaves injured by rows of holes cut across the blade are the work of the corn bill-bugs. The injury occurs when the plant is a few inches high, and the leaf blade is still within the sheath of the cornstalk. The holes do not become conspicuous until the blade has grown out. Since the blade is curled up within the leaf sheath, one hole made in the leaf sheath means six or eight holes in the curled leaf blade. Corn planted on timothy sod that has been infested with these grubs is likely to be damaged, especially if the sod has been turned under in the spring.

It has been found that the early fall or summer plowing of

sod lands which are infested with these grubs, greatly reduces the injury if corn is put in the field the following year. The stirring of the soil disturbs the insects so that they are unable to survive the winter.

Army worm.—The army worm resembles the cut-worm. The color varies from yellow to brown or black. There are three stripes, a middle black one and an upper and lower yellowish one, on each side. The worm pupates in the soil. The pupa gives rise in ten to twenty days to a moth. The moth is a night-flying insect and is often attracted in large numbers to light. The fore wings of the moth are yellowish-brown in color and are marked with a small white speck near their center. Each female moth is capable of laying about 700 eggs.

These eggs hatch into small green worms in about eight to twelve days. The young worms eat but little and feed close to the ground. They may be in a field in great numbers and still escape detection. The worms are nearly full grown before injury becomes serious. Three to five weeks are required for full growth. The worms then are one and one-half inches long and one-eighth of an inch wide.

While the army worms prefer to breed and feed in grass or small grain growing in low and moist parts of fields, they become so abundant and food material so scarce that the worms are forced to seek other places for their food. On such occasions, the worms migrate in vast armies and enter a cornfield if it is in their path. The migrating worms climb the stalks and strip the plants of their leaves. The worms hide during the daytime under clods of dirt and rubbish, and feed during the night.

There are several control measures for the army worm. Infested areas may be mowed, covered with straw and burned. If migrating, the worms may be destroyed by spraying, by scattering poisoned bait, similar to that used for cut-worms, or by trenching, as described for the chinch bug.

Grasshoppers.—There are several species of grasshoppers. Almost every one is familiar with the ordinary adult which does the damage to crops. The habits of the usual species are much

alike. The grasshopper has no larval stage. The grasshoppers usually lay their eggs in the fall of the year and then die. The eggs are laid in masses in the ground. As many as 127 eggs have been found in a single egg mass laid by one of the large species of hoppers. Each female ordinarily produces two egg masses. The eggs remain in the ground over winter. The following spring, during May and June, the eggs are hatched. The young insects feed and grow and at intervals shed their hard skin. After the skin has been moulted for the fifth time, the insect is fully winged and the females are ready to lay eggs.

Ordinarily, grasshoppers do not breed in cornfields, but may invade such fields from neighboring ones where alfalfa, grain or grass is grown, or from unplowed edges of fields and roads. They eat the leaves, silks and husks of the corn plant.

There are several control methods. Poison bait made as follows is good:

Bran or mixed bran and sawdust	25 pounds
White arsenic or Paris green	1 pound
Salt	1 pound
Cheap molasses	2 quarts
Water	10 quarts
Amyl acetate (technical)	1 ounce

This amount of bait is sufficient to scatter over two acres. It should be scattered early in the morning.

Corn ear-worm.—The ear-worm is the common greenish or brownish worm that eats into the ears of both dent and sweet corn. The adult is a brown moth.

As there are three generations in one year, and each female produces 200 to 300 eggs, this insect can increase rapidly. They pass the winter in the pupal stage. The moth emerges early in the spring and deposits eggs which hatch by the time corn is planted. The first two generations live on the leaves, but the third generation attacks the ears.

The ear-worm is especially damaging to sweet corn. In the South it plays havoc with the dent varieties. The young worm begins to feed on the silks and kernels at the tip end of the ear.

The full-grown worm tunnels down the ear toward the butt end. The same worm feeds on the cotton boll, the tomato and tobacco bud.

There appears to be no reliable measure for controlling the corn ear-worm. Fall plowing has often been recommended, but it is doubtful if this measure is effective. The insects breed with such rapidity during the summer that any benefit of fall plowing is overcome. Some benefit has been obtained by dusting sweet corn during the silking period, with powdered lead arsenate, but this is not practical except with sweet corn. Varieties that have long, tight-fitting husks are protected to a certain degree from the work of this worm. Late-planted corn seems to be more susceptible to ear-worm damage than early-planted corn.

The ear-worm should not be confused with the extremely injurious European corn borer, which is described later.

American stalk borers.—There are several kinds of stalk borers. The chief importance of these insects is the possibility of confusing them with the much-feared European corn borer described further on.

One stalk borer commonly found in the Corn Belt has broader, darker brown stripes than the pale stripes of the European borer. It does its work early in the season, whereas the European borer is most active after tasseling time. The American stalk borer does little damage and its control is not important.

Insects that Work on the Entire Plant

European corn borer.—The adult is a moth which flies from place to place during late June and early July and deposits eggs on corn leaves of plants 2 or 3 feet high. It is not attracted by plants less than a foot high. These eggs hatch into small, smooth caterpillars which bore into the stalk. The entire plant, including tassel, stalk and ear, is invaded. Damage does not become apparent until August.

The larvae pass the winter in the stalk. The borer is rather light in color, with a row of small, dark-brown spots on each segment, while several dark brown or pink lines extend lengthwise of the body. Because the adult is a moth, the borer is easily spread. The moths either fly or may be blown for great distances.

It is one of the worst pests of Hungary. It was introduced into Massachusetts in 1917, and into southern Ontario, just across the lake from Ohio, about the same time, or perhaps a little earlier. The Ontario infection spread about 1920 to Ohio

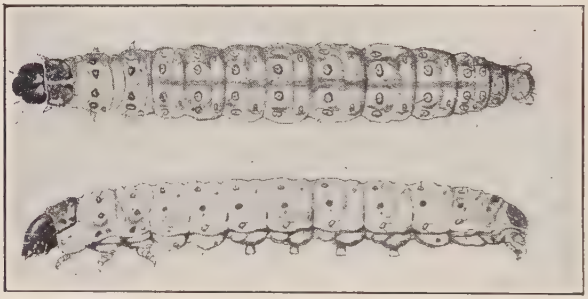


FIG. 49.— European corn borer (*greatly enlarged*). The full-grown caterpillar is about one inch long.

and Michigan. Little serious damage has been caused at this writing, in 1928, in either Ohio or Michigan, but the pest is spreading rapidly, and it is known from the Ontario experience that in a few more years northern Ohio corn growers will be suffering severe damage unless they are willing to co-operate in plowing all cornstalk ground in such a way as to turn under all stalks and other vegetable matter. That this can be done practically has been demonstrated beyond all doubt. Ideal equipment is an 18-inch plow equipped with running coulter, jointer, and three wires attached to the axle of the plow. It is not necessary to plow more than 6 inches deep with such equipment because the big object is to leave nothing on the surface under which the borers can hide. It makes no dif-

ference if the borers come to the surface if they have nothing to hide under because they perish quickly when unprotected. The plowing can be done any time previous to the middle of May.

During the early years of its invasion the borer causes very little damage. In fact it is necessary to have about 10 borers in a stalk before the damage becomes serious. For this reason it is easy for farmers to become skeptical about the seriousness of the borer during the first five years of the infestation. Some entomologists say that in the drier climate west of the Mississippi the borer may not thrive nearly as well as in the cooler, moister climate of New England and northern Ohio. Excellent information on the European corn borer is contained in Circular 321 of the Illinois Station at Urbana and Bulletin 1562F of the United States Department of Agriculture at Washington. Sooner or later, the pest is certain to reach the center of the Corn Belt, but its progress can be much delayed if the state and federal authorities keep continually on the job and are able to get the whole-hearted co-operation of the farmers in infested districts.

The European corn borer has possibilities of causing as much damage to the corn crop as the boll weevil has caused to the cotton crop. There is grave danger that it will reach the heart of the Corn Belt by 1933.

Insects that Work on Stored Corn

There are several insects of stored corn, only a few of which are mentioned in this chapter. On account of the severe winters, they ordinarily do not damage corn greatly in a large part of the Corn Belt, especially the northern section.

The Angumois grain moth, the Mediterranean flour moth and the weevil are three insects of stored corn that are often found in large numbers where the storage temperature is above freezing during the winter. The weevil is injurious to the stored grain of many crops. The small brown adult beetle punctures the kernel and inserts its egg. The white larva or grub lives

inside and eats the kernel. Several may be found in one kernel. The pupal stage is white and transparent. The Mediterranean flour moth is injurious to many grains, especially wheat. The adult is a small gray moth. The silken webs spun by the larvae are troublesome. The Angumois grain moth is not numerous in the Corn Belt. The small round holes in a kernel of corn are indications of attack by this insect. The moths are light brown in color. The larva is a small, whitish worm.

Under farm conditions, the practical control is fumigation with carbon disulphide, a heavy liquid, which is volatile. The gas formed is heavier than air, and so the liquid must be placed at the top of the room or buidling to be fumigated. One pound is sufficient for 50 to 100 bushels of grain, depending on the temperature and the type and size of building fumigated. The gas is highly inflammable, and so all lights and fires should be kept away from the building being fumigated. It is also slightly poisonous. Hydrocyanic gas is effective but extremely poisonous. Heat may be used in mills or elevators as a remedy. An effective fumigant which is not inflammable, like carbon bisulphide, is a mixture of 40 volumes of ethyl acetate and 60 volumes of carbon tetrachloride. It requires about 45 pounds per 1000 cubic feet. This mixture may eventually displace carbon bisulphide as a fumigant, but at this writing is still in the experimental stage.

Other pests.—Birds, like the blackbird and crow, eat a large amount of the planted seed, and in some cases part of the crop. Rodents and rabbits often cause a reduced stand by eating the seed. Some farmers attempt to poison these pests. Others spread a bushel or so of well-soaked corn around the edges of the newly-planted field of corn. The pests feed on this soaked corn and do not disturb the planted seed.

DISEASES OF CORN

Corn is freer from disease damage than most other crops. The two important groups of diseases of corn are corn smut, with which every corn grower is familiar, and the rots (Fusarium, Diplodia, etc.). Previous to 1913, much of the damage caused by the latter group of diseases was attributed to the corn root-worm, the corn root-louse, or to drouth. There are possibly ten different bacterial or fungus organisms which play some part in root or ear rotting, stalk stunting, leaf rolling, joint discoloration or leaf reddening in the cornfield.

Corn Smut

All corn growers are familiar with the black balls of corn smut which are found in every cornfield. It is a typical fungus with the mycelium growing inside the stalk or leaf of the corn plant. Externally, smut first appears as a rather lustrous, lead-colored bump, but this bump swells and darkens until it bursts and lets loose the black smut spores, which are in effect the seeds which carry over the disease in the soil for another year. In the average field, smut causes the loss of one-half to one bushel an acre, but in many fields it causes the loss of two or three bushels an acre. The accompanying map, based on information compiled by the U. S. Department of Agriculture, indicates that smut is a much more serious matter on the extreme southwestern edge of the Corn Belt than it is in the central part. Possibly extreme drouth and heat are favorable to the development of corn smut.

No one has discovered any effective way of preventing corn smut. Rotation helps some. After corn has been grown on the same field for more than two years, the infection seems to become worse. Theoretically, it should help to go over the field several times in July and August and pick off the smut balls before they burst, but this is absolutely impracticable. Treat-

ing the seed with formaldehyde, in the same way as small grain is treated for smut, does not reduce the percentage of smut. The one practical method of attack is to breed for strains of corn which are smut resistant. At the Minnesota and West Virginia experiment stations it has been proved that some strains of corn are completely immune to smut on badly infested land where other strains have 30 per cent or more of the stalks infested. It would seem to be worth while to avoid picking

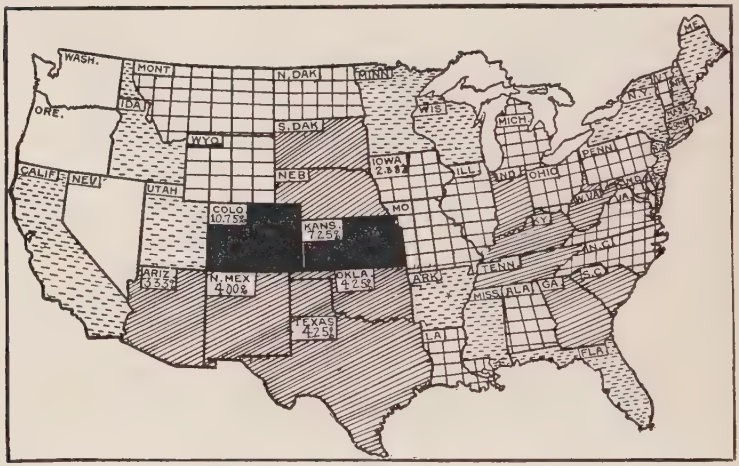


FIG. 50.—Estimated percentage of corn crop destroyed by smut. Solid, over 5 per cent. Diagonal lines, 2.6 to 5 per cent. Squares, 1.1 to 2.5 per cent. All others under 1.1 per cent.

seed ears from stalks which show even the slightest signs of smut infection. The constructive corn breeders of the future will do some of their best work in developing high-yielding strains of corn which are much more resistant to smut than any we now have.

Corn smut is not poisonous. It has been fed in large quantities to livestock without bad effects. In fact, an eastern experiment station states that it makes an excellent substitute for

mushrooms, for human consumption, if gathered before reaching the bursting stage.

In the Corn Belt and most other corn-growing sections smut is caused by Ustilago zea. In Washington and Oregon, however, smut in corn is caused by another fungus, Sorosporium reilianum, or head smut of sorghum.

Courtesy of Iowa Station.

FIG. 51.—Corn smut.

ROTS

The large group of diseases classed under the name of rots is known to be caused by one or more species of the following fungi; Diplodia, Fusarium, Rhizopus Mucor, Verticillium, Penicillium, Aspergillus and Gibberella. Bacteria are responsible for some of the rots.

Probably the most clear-cut and outstanding of the rot diseases of corn is Diplodia, which infects the entire plant but manifests itself most noticeably in the form of moldy ears—ears which are moldy altogether apart from any mold following

damage by the corn ear-worm. White streaks of mold found between the kernel tips are signs of Diplodia. In bad cases, the entire ear will be a mass of white mold. Many apparently good seed ears are slightly infected with Diplodia, and when planted produce a very high percentage of stunted and barren stalks. One of the most important things to look out for when shelling the seed ears by hand is to throw out any which show the slightest trace of mold at the kernel tips. Diplodia is doubtless carried over from one year to the next in the soil as well as in the seed corn, but there is apparently nothing that we can do about the presence of the disease in the soil. Diplodia does not do so very much damage if strong, mold-free seed is planted, provided the late summer and early fall are not unusually moist and warm. In 1922, Holbert, of the U. S. Department of Agriculture, began treating seed corn with different substances to prevent Diplodia damage. After five years of work, it seemed that organic mercury dusts were most effective in increasing the germination and vigor of seed which was infected with Diplodia. The treatment was to dust the seed corn with a tablespoonful of the dust to a peck of corn or 2 ounces to the bushel. Circular 34 of the U. S. Department of Agriculture gives a quite complete account of the method of treatment, etc. While there is much variation, it seems that the yielding power of ordinary seed corn is usually increased a bushel per acre and of diseased seed 5 or 10 bushels per acre. Inasmuch as the cost of treatment per acre is only 5 cents these dust treatments seem worth while. In the western part of the Corn Belt the dust treatment seems to be less worth while than in the eastern part.

There are many species of Fusarium attacking a great variety of plants. Ordinarily, they are not so very serious. One of them, when weather conditions are just right, causes scab in wheat. It has been definitely demonstrated that the same Fusarium (Gibberella s. is a type of Fusarium) may, when corn is following wheat, cause very serious damage to corn. There are several other Fusaria infecting corn, and most of

them are carried over winter not only on the cornstalks but also inside the kernels of corn. No method of treating the corn with formaldehyde will free the kernels from infection. Apparently all that can be done is pick out the ears that are infected and avoid planting them. Illinois experiments indicate that seed which is infected with Fusarium will yield fully 20 per cent less than disease-free seed. Iowa experiments indicate that under favorable conditions of soil and weather there is very little difference in yielding power between seed infected with Fusarium and seed not infected. There is no question about the low-yielding power of seed infected with Diplodia, but there seem to be some conditions under which some Fusaria are not so very serious.

One interpretation of the rots.—Hoffer, at the Indiana station, has proved that on soils lacking in phosphorus, potassium and lime, corn plants are susceptible to absorbing iron and aluminum from the soil. Iron settles at the joints of the corn plants and clogs up the food-carrying canals of the plant. Aluminum settles in the leaves and causes a type of leaf firing. Both iron and aluminum make the plants unhealthy, and as a result they are easy victims for the rot diseases. Hoffer has proved that some strains of corn are especially good in poor soils in the matter of resisting iron and aluminum temptation; that they make a special effort to find the healthful phosphorus, potash, etc., even though the soil is exceedingly poor in these true plant foods. These strains of corn are also unusually good in resisting root rots and stalk troubles. Holbert has proved that certain strains are unusually resistant to the rot troubles, but he thinks that rot suscepibility is often linked with a liability to chilling at temperatures no lower than 45 degrees.

Controlling the rots.—From the standpoint of practical action against the rots, the first thing is to select normally matured ears from normal stalks in the field. Go over the seed ears and throw out all having kernels with starchy backs. Throw out the ears that are light for their size and show any sign of disease at the shank. Shredded, dull-colored shank

attachments indicate disease. The next step is conducting the germination test with unusual care and with an eye open for signs of infection. However, the Ohio station states that although experts can use the germination test to select disease-free ears, the average person can not make practical use of the germination test from the disease standpoint. There are two methods of testing for diseased ears. One is a table germinator with a limestone-sawdust base. The other is a modified rag doll.

Modified rag doll.—The following directions are designed to help in constructing the special form of rag doll to pick out rot-infected ears:

1. Lay a 12×60-inch strip of firm, water-finish fiber (butcher's paper) on a table.
2. On top of the paper lay a 12×54-inch moistened strip of muslin.
3. Place eight representative kernels from each ear in a row, with germ sides down and tips pointing in the same direction.
4. Roll the paper and cloth into a doll, as described in the making of the rag doll.
5. Store the dolls in a warm, moist place for seven days.
6. The stored dolls should not come in contact with one another.
7. A box with wire cross rods 3 inches apart in the upper part of the box is suitable for storage.
8. Keep the dolls moist and see that the container allows drainage.
9. Unroll the dolls and read the test.
10. The percentage of germination of each ear is determined in the usual way, and the seedlings are then examined for molding or rotting. The seedlings which have discolored or rotten stems or roots, or which come from rotten kernels indicate ears infected with disease.

In Franklin county, Indiana, there is a large community seed corn-testing plant in which hundreds of thousands of ears are tested with the modified rag doll. The Indiana farmers who send in their seed ears to this plant are given back the corn which has been proved by the testing plant to be of high germinating power and free from disease. In Indiana and Illinois it is believed that such corn will yield fully 10 bushels more per acre than ordinary seed corn. On the richer soils of Iowa and

Nebraska there does not seem to be so much advantage in favor of the corn which has been proved to be free from disease.

At the Nebraska station, Kiesselbach found that the important thing was to pick horny, smooth kernels. This type resists disease better than the rough, starchy sort, but under Nebraska conditions the horny, smooth type seems to have a merit altogether apart from disease resistance.

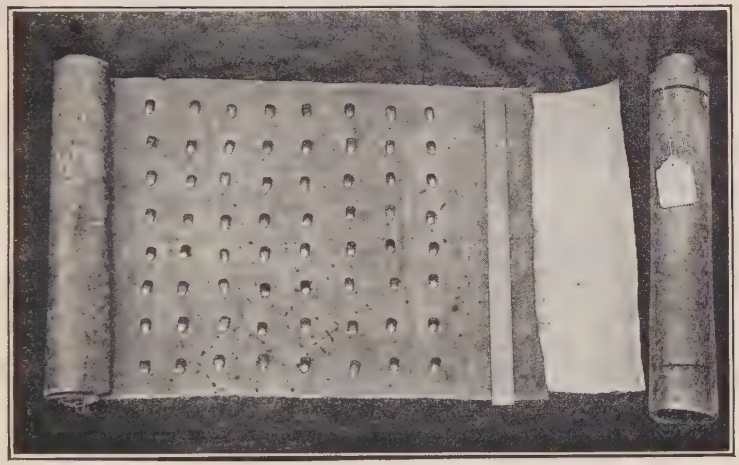


FIG. 52.—Placing eight kernels from each ear in the modified rag doll.

Disease-resistant corn.—Holbert and Hoffer have proved that some inbred strains are remarkably resistant to rot troubles. Moreover, when these unusually resistant inbred strains are crossed, they produce very high yields and the stalks stand up strong and straight. It would seem, therefore, that the most constructive work in controlling root rot diseases will be done by the plant breeder who brings about productive combinations of strains which are resistant to disease.

Effect of soil.—Soils rich in phosphorus, potash and lime, which have been under a rotation with clover once every four years and with corn not oftener than two years in succession,

are not bothered seriously with the rot diseases. Poor soils are greatly benefited by an application of 2 tons of limestone and 200 pounds of acid phosphate per acre, together with clover in the rotation. Treatment of this sort seems to be especially necessary on the tight clay soils of Indiana if serious rot trouble is to be avoided. On a few soils in the eastern and southern part of the Corn Belt it is necessary to apply potash although usually lime, phosphate, clover and manure will take care of the rot troubles.

Conclusion.—In the present state of our knowledge, the practical way of handling these diseases is to apply lime to acid soils, grow clover once in four years, avoid growing corn on the same land more than two years in succession, burn the cornstalks, avoid following scabby wheat with corn, and plant seed corn which the germinator indicates to be disease-free.

FIG. 53.—Keeping the modified rag doll moist.

By 1930 it is probable that either the experiment stations or the seed companies will have available special high-yielding strains of corn which have been definitely proved to be resistant to the entire group of rot diseases and smut and other corn diseases as well.

Other diseases.—Corn rust is a common disease of the plant. This disease affects mainly the leaves and tassel of the plant, and interferes with their functioning. However, the damage is not great, and little attention has been given to control measures. Other diseases of corn are sheath spot, wilt and damping-off.

CHAPTER X

RAISING CORN FOR FODDER AND SILAGE

Corn fodder is the source of a large amount of feed for all types of livestock. The entire plant, including ears, is referred to as corn fodder, while the stalks without ears are called corn stover. This chapter will deal with both corn fodder and stover, and also the method of handling corn for silage.

Choosing the varieties for fodder and silage.—In the present state of our knowledge, the safe thing for most Corn Belt farmers to do is to stick by the regulation grain sorts as commonly grown in the community, since the grain is the most valuable part of the plant. Approximately 60 per cent of the digestible food materials present in the corn plant are found in the ears, and 40 per cent in the stover. Eventually we shall do as in New York and New England, where almost invariably a different variety is used for fodder than is used for grain. Our present varieties are not perfect. They blow down too easily. A two-eared sort of Reid or Leaming might be well worth while for fodder and silage and a little later sort may better be used for fodder than for grain.

The large, late-maturing varieties from the southern states have in some cases given a larger amount of dry matter than the adapted local varieties, but as the difference is relatively slight and the quality of fodder and silage relatively poor, and a much greater tonnage of green fodder must be handled, owing to the greater percentage of water in the more immature southern varieties, those adapted to the locality are considered more profitable.

It is desirable to plant corn which is to be used for fodder or

silage just as early as if the crop were to be harvested for grain only. The corn should mature early enough to be ready to harvest before frost, as only in that way is the maximum yield

FIG. 54.

of dry matter obtained. In some instances, when it has been found necessary to plant a field of corn rather late in the season, it has been found desirable to use the replanted corn for fodder.

as the crop will often become sufficiently mature before frost to make a fair quality of fodder or silage when it would not do to crib.

Planting for Fodder or Silage

It really makes little difference whether corn for fodder or silage is drilled or checked. If the land used is very weedy, checking undoubtedly will be the safest method, as the weeds can be better kept under control by cultivating in both directions. On clean ground, drilling is often preferred, as the plants will be more uniform in size and the corn binder will run more smoothly, since the stalks are cut one at a time. On very fertile, clean ground, a somewhat greater yield may be secured by drilling.

Rate of planting.—Corn for fodder or silage may be planted a little thicker than for grain, as a greater yield of both grain and fodder usually will result. The rows are placed $3\frac{1}{2}$ feet apart and the kernels dropped so that there will be one stalk every 9 or 12 inches in the row when drilled or three to five stalks per hill when checked. The thickness of planting should depend somewhat upon the fertility of the soil, the variety of the corn, the amount of rainfall in the region and to some extent upon the length of the growing season. If the corn is planted too far apart, the stalks grow rank and woody, there is a tendency to mature late, and also the yield will be reduced. On the other hand, if the corn is planted very thick, the percentage of grain will be reduced. Table XII, Chapter VI, giving the results with different rates of planting at the Ohio station, indicates that on fairly rich land in the north-central part of the Corn Belt it pays to plant somewhat thicker for both fodder and silage than most farmers have been in the habit of planting. Generally speaking, corn for fodder or silage should be planted about 40 per cent thicker than for grain. Probably the greatest drawback from thick planting is the increased tendency for the corn to blow down.

Harvesting

Time to cut.—The best results are obtained by cutting when the kernels are well dented and hard and the lower leaves of the plant turned brown. At this stage, the corn plant has its greatest feeding value. In addition, it is in good condition to put into the silo.

Although there is some difference of opinion as to the best time to harvest corn for silage, it is generally conceded that immature corn does not make the best quality of silage. When corn is cut too early, the silage has a dark color, contains too much acid and some of the feeding value is lost. Some farmers prefer greener silage for feeding to dairy cows than for feeding to beef animals. For the value of corn at different stages of growth, see Table IX, Chapter III.

Of course, it is desirable not to allow the corn to become fully ripe because the plants become more woody and leaves are lost. If, however, the corn becomes over-ripe before cutting, a good quality of silage can be made if a little water is added by running it into the top of the blower with a hose while the silo is being filled. Sufficient water should be added to make it possible to pack the silage firmly.

Method of harvest.—Corn for fodder or silage may be cut by hand, with a sled or platform cutter, or with a binder. Cutting by hand is slow work, requiring fully three times as much man labor as with a corn binder. Hand cutting is almost never used in the Corn Belt except when the corn is badly down. The sled or platform cutter requiring two men to operate is a cheap machine which does not get out of order. However, the two men find the work much harder than the single man who drives the corn binder. The corn binder, because it is faster and easier on the men, is almost universally used in the Corn Belt, in spite of the fact that it is a rather expensive machine which gets out of repair rather easily. In using the corn binder, it is well to make the bundles rather small if the corn is to be put into the silo, because small bundles make loading easier and enable the

corn to run through the silage cutter more smoothly. Usually three horses are used on a corn binder, although occasionally four are put on.

FIG. 55.—Binding corn and elevating the bundles with an attachment to the corn binder.

TREATMENT AND USE OF FODDER AND STOVER

Shocking corn fodder.—Ripe corn should be shocked as soon as it is cut. If the corn is green and full of moisture, it should be allowed to lie on the ground for a few days. The shocks should be large, containing about forty medium-sized bundles. Two men working together can build a firm shock by setting the bundles in an upright position, the butts firmly on the ground, and bracing the shock from all sides. The tops of the bundles may be closely compressed together with a small rope that has a

ring in one end. Binder twine may then be used to hold the tops together and the rope released for use on the next shock. A shock of this type should stand a year with a minimum amount of waste.

A practical farmer reports that he has had good results in building shocks by setting several bundles horizontal and crosswise of each other with the ears of the bottom bundles on the stubs of a hill of corn. He then fits the upright bundles in around these crossed horizontal bundles and has a shock which will stand up stiff and straight.

Losses in corn fodder.—There is a loss of feed value in both silage and fodder. However, the loss in the latter is greater. No matter how well shocked, corn fodder will lose in value. Corn fodder or stover standing in the field for a few months, according to Henry and Morrison, loses 20 per cent of the dry matter it contains, due to weathering and fermentation. They say that the losses are in the sugar, protein and starch, the most valuable parts.

Utilization of fodder.—Corn fodder may be utilized in any of the following ways:

1. Soiling crop—cut green and fed.
2. Dry corn fodder—cured in the shock.
3. Shredding—ears removed and stover torn in small pieces.
4. Stover—ears removed and stover fed.
5. Silage.
6. Miscellaneous uses.

Corn as a soiling crop.—Because of poor pastures in the late summer, many farmers feed green corn to their livestock. Usually the corn is cut daily and fed. This corn is palatable and relished by all kinds of livestock. More corn is used this way than is generally realized. Sweet corn and early varieties of dent corn may be used to good advantage, for they are ready to feed early in the season.

Dry corn fodder.—The cured corn fodder (shock corn) may be fed directly from the shocks or from stacks where it is stored for ease in feeding. Fodder should not be put in stacks or mows

until it is cured. The stacks should be narrow and not over 10 feet high, and it may be advisable to put layers of straw or hay between the layers of fodder bundles. There is some waste in both corn and stover in feeding fodder. It is not nearly so valuable as silage. Corn may be thickly grown and cured to make a coarse hay.

Shredding.—Most of the shredding machines now used husk the ears from the fodder and then tear the stover into small

FIG. 56.—Shredding corn fodder.

strips. The husked ears are elevated into a wagon and the shredded stover is elevated or blown into the barn or stack. The shredded stover is easily handled, and there is less waste than in ordinary stover. The shredded stover makes good bedding. Large piles of shredded stover heat easily, especially if the stover is green. The addition of salt helps to keep down heating. Usually, shredding is done late in the season. The customary charge for shredding is usually around $4 an acre. The practice is most popular in the eastern and northern sections of the Corn Belt.

Corn stover.—Often the ears are removed from shock corn and the stover fed directly to livestock as a roughage. The stover of small, early varieties as grown in the northern Corn Belt is of good quality. Stover may be fed to all classes of livestock and will " carry over the winter " cattle and idle horses.

Miscellaneous practices.—In some sections, especially in new regions where machinery is scarce, corn fodder is run through an ordinary threshing machine. The grain is shelled and the stover blown into the barn or stack. In the south, corn is topped—stalk cut off just above the ear—and the leaves are stripped from the stalk for feed. This practice is often followed to hasten maturity. However, the practice is not recommended, for it reduces the yield of ear corn very greatly.

There is a special machine for making stover silage. The corn fodder in this case is run through the machine and the ears are husked and cribbed and the stover is put into the silo.

Standard day's work.—Under favorable conditions, the following number of acres can be handled in a ten-hour day:

Cutting:

Binder, 40-bushel corn, one man, three horses	8.0
Platform cutter, 40-bushel corn, two men, two horses	6.0

Shocking and cutting by hand:

After binder, two men	3.6
Cut and shock by hand, one man	1.4

CORN SILAGE

Why corn should be put into the silo.—Silage aids the farmer to utilize fully the food value of the crop which he produces. Corn properly stored in the silo saves more of the food value of the plant than is possible by any other method. Not only is there a saving in food value, but the crop may then be fed practically without waste. Silage is very palatable and is readily eaten by almost all classes of farm animals, being espe-

cially well suited for cattle and sheep. Silage furnishes a succulent feed in winter when greatly needed and is also a valuable supplement in late summer and early fall when pastures are likely to be short. When corn is harvested as silage, the farmer is less dependent upon the weather, and the crop is stored in a smaller space and more convenient form for feed than it is possible to store the same amount of corn as dry fodder.

The use of silage crops dates back to the time of Caesar. The Romans stored green feeds for their horses in the ground. The Germans made use of silage for animal feed many centuries ago. However, silos have been in use in the United States only during the last half century. Since their introduction, the number has increased rapidly, until the " watch towers of prosperity," as they are called, dot the entire Corn Belt and the great dairy states.

There are about half a million silos in the United States, of which about one-third are found in the dairy sections of Wisconsin, New York, Minnesota and New England. In the dairy sections, silos are found on every third or fourth farm, whereas, in the Corn Belt proper, silos are found on about one farm in ten.

Selecting the kind of silo.—There are many kinds of silos in use to-day, but there are only two general types:

1. Pit silos—built partially or wholly below ground.
2. Above-ground silos—built of wood or masonry.

The first type is found only in the western edge of the Corn Belt and the plains section. The second type includes nearly all the silos of the Corn Belt. No attempt will be made to describe the building of either type. But the desirable features of a well-built silo may be stated as follows:

1. The walls should be as air-tight as possible.
2. The walls should be strong enough to resist the pressure of the silage.
3. The inner surface of the wall should be smooth.
4. The location and construction of the silo should prevent freezing.
5. It should be built to resist high winds.
6. It should be cylindrical in shape and have plenty of depth.
7. It should be convenient for filling and emptying.

8. The foundation should be durable and extend below the frost line.
9. A permanent silo of neat appearance adds much to the farm.
10. The silo should be simple in construction and low in cost.

The Silage Process

Silage is finely chopped green material packed in an air-tight receptacle. All reference, unless otherwise noted, will be to corn silage, for it is the common silage used. The making of silage is a fermentation process, which begins as soon as the silo is filled. The following changes are brought about:

1. Increase in temperature—85 to 90° F.
2. Evolution of carbonic acid gas—dangerous in pit silos.
3. Change in color—darker.
4. Aromatic odor—desirable.
5. Formation of acids—1 to 2 per cent of weight.
   (*a*) Lactic acid—acid of sour milk.
   (*b*) Acetic acid—acid of vinegar.
6. Formation of alcohols—1 to 4 per cent of weight.
7. Breaking down of proteins—no loss to silage.

These changes, which are bacterial, physical and chemical, are practically completed at the end of two weeks, and the silage is made. Silage may be kept for years in a tight silo without loss of palatability or value. It is important, however, that the silage be well packed and the silo very tight, because air permits the development of molds, which are sometimes poisonous and which quickly destroy the acids and thus allow the silage to spoil. Bacteria which cause decay will not live and work in the presence of lactic and acetic acids when no air is present.

Common yields of silage.—Under average conditions, a 50-bushel crop of corn will produce eight or nine tons of silage per acre. With the varieties as ordinarily grown in the Corn Belt, and with the customary rates of planting, silage normally runs about 6 bushels to the ton, which indicates that as a rule a 42-bushel yield of corn means a 7-ton yield of silage. With the rank-growing southern varieties of corn there may be only three or four bushels of corn per ton, whereas with some strains

of Reid there may be as high as seven or eight bushels of corn per ton of silage.

Hauling to the silo.—Most of the corn fodder for the silo is hauled on ordinary racks. A low-down rack has some advantages in loading. The general custom is to have about seven wagons hauling, with an extra man at the cutter to help unload. Bundles are laid flat on the rack, with butts one way. Usually the bundles are hauled as soon as the corn is cut. As a rule, two men are used in the field to hand up bundles to the man on the wagon. One of these men may be eliminated, however, and considerable hard work dispensed with if the corn binder is equipped with a bundle elevator so that the wagon can be driven alongside the binder as it cuts. The objection to this plan is that if anything goes wrong with the binder, there is no corn cut ahead and the whole crew is laid up until the binder is repaired.

Filling the Silo

The man who feeds the corn to the ensilage cutter affects very directly the progress which is made. He determines the length of the pieces into which the silage is cut. An important precaution is to see that the knives of the cutter are sharp at all times. Two or three sets of knives are maintained for most cutters, so that they may be changed or re-sharpened once or twice a day.

Adequate power to drive the cutter is another prerequisite to efficient silo-filling, whether the source of power is a gas tractor or a steam engine. A large cutter and a small engine will slow up the operations. Reserve power is highly important if the cutter is to run smoothly and do the best work. In Missouri Bulletin No. 226 it is stated that, " The maximum capacity of a silage cutter in tons per hour is about the same as the width of the throat in inches; and the horse power required is from one to one and a half times the capacity in tons per hour."

Stake the cutter down firmly in a place where the teams can

get to it easily, and where the blower pipe can be placed as nearly as possible straight up and down. Line the engine up with the cutter so that the belt runs smoothly. The rule for size of pulleys on engine and cutter is: Multiply diameter of engine pulley in inches by its speed in revolutions per minute and divide

FIG. 57.—Low down racks save labor at silo-filling time.

by the revolutions per minute the silage cutter is supposed to run. The answer is the proper diameter of the cutter pulley in inches.

Much difference of opinion exists regarding the length to cut corn for silage. Some farmers prefer one and one-half inches,

while others advocate cutting not over one-half inch. The longer cuts are more economical of power and the silo may be filled more rapidly, but the silage will not pack as closely in the silo. Therefore it may not keep as well, and in addition there is more waste in feeding. All things considered, the one-half inch or three-quarter inch cut is probably the most desirable, as it packs readily and feeds out with but little waste.

Distribute and pack well.—The heavy and light portions of the finely cut corn must be uniformly distributed. The heavy part of ears and stalks should not be in the center or on one side, and the lighter part, such as leaves, on the other side, as settling will be uneven and much spoiled silage will result. In order that the full capacity of the silo may be utilized, and at the same time insure a good quality of silage, it is essential to distribute the cut corn uniformly and firmly tramp all parts of the silo, especially the outer edge. The work of distributing the cut corn and packing it is greatly facilitated by the ordinary distributor.

When a large quantity of corn is placed in a silo within a short time, a considerable settling of the silage results, making it necessary to refill the silo within a few days in order to utilize its full capacity. Where two silos have been built side by side, filling one for a day, and then filling the other for a day until the two silos are filled, partially overcomes the difficulty from settling.

Adding water.—If corn is cut at the proper time, good silage can be made without adding water. Corn in the silo at filling time should feel moist. Briefly, water should be added to corn when filling the silo under the following conditions: First, when corn is too ripe and does not pack well in the silo; second, when refilling the silo in the late fall or winter with dry shocked corn.

Preventing waste on top.—Unless feeding is commenced as soon as the silo is filled, some corn at the top of the silo will spoil. This waste may be partly eliminated in several ways. First, level off the surface and tramp firmly. Some farmers

use finely cut straw or chaff from the straw stack thoroughly packed and wet down, to cover the top. Others soak the top with water and sow oats. The oats sprout and make a thick covering which keeps out the air and reduces the waste. Satisfactory results have come from the use of tar paper spread over the surface and covered with a thin layer of cut corn from which the ears have been removed. In any case, it is a good plan to pull the ears off the last load of corn which is put into the silo.

Opening the silo.—Corn may be fed as soon as the silo is filled, but for the first few days, it is nothing but green corn finely cut. When handled in this way, there is no waste on the top of the silo. During the first ten days or two weeks, fermentation takes place, and the corn is gradually changed to silage. When silage has been allowed to stand for a time before using; the spoiled layer should be thrown away.

Refilling the silo.—After the contents of the silo have been fed out, the silo may be refilled with dry shocked fodder, if it is available. Dry corn put into the silo makes a very satisfactory feed, but it is not as high in value as silage from corn put in at the proper stage. In refilling a silo with dry corn fodder, about 250 gallons, or one ton, of water should be added to each ton of dry fodder. The water may be run into the top of the blower with a hose. It is not desirable to allow the water to run in one place, as it will follow channels and leave parts of the silage practically dry, resulting in much spoiled feed. Corn stover may be used in the above way but its feeding value is much lower than silage made from fodder. These types of silage should be made not later than February 1.

Problems of Silage

Frosted corn silage.—If the corn which is to be used for silage is frosted while still quite immature, it is best to cut it soon after frost, to avoid loss of leaves and allow the corn to cure out to some extent before putting it into the silo. In 1915, when

much immature corn was harvested for silage, many farmers cut their frosted corn, cured it in the shock, and filled their silos later in the season, adding water to facilitate the packing of the silage. Some of the farmers who put this kind of corn into the silo immediately found that the silage produced was very watery. Soft corn silage is discussed in Chapter III.

Corn silage versus other silage.—As far as its content of protein and sugar is concerned, the corn plant furnishes the most nearly ideal single plant material for silage. Plants similar to the legumes contain too much protein material in proportion to the sugar content. Sunflowers give a large tonnage, but a coarser silage. Dairy sections in the southern Corn Belt infested with the chinch bug have grown sunflowers for silage with only fair results.

Legumes, especially soy beans, have been mixed with corn for silage. Ordinary corn and soy-bean silage, resulting from growing the two crops together in the same field, usually has ten parts of green corn to one part of soy beans. The Indiana experiments indicate that the advantage of corn and soy-bean silage is more theoretical than actual. Apparently, any slight increase in the value of the silage per ton, or in the yield of the mixture per acre, is counterbalanced by the cost of the soy-bean seed and by the extra bother involved in handling the mixture.

Characteristics of good silage.—In buying, feeding or judging silage, it is well to know the characteristics of good silage. Good silage should have the following characteristics:

1. Cut in half-inch lengths (not long shreds).
2. Very leafy with few coarse stalks.
3. A large amount of grain in the stover.
4. Sweet and free from all molds.
5. Sharp odors of acid.
6. No odor of spoiled butter.
7. Even distribution of moisture.
8. From 60 to 74 per cent moisture.
9. Light in color.
10. Palatable.

Feeding silage.—Silage is ordinarily fed to dairy cows at the rate of about 30 pounds per head daily, in connection with 10 pounds of clover or alfalfa hay. With beef cows, an excellent ration for carrying through the winter is an average daily of 35 pounds of silage and 4 or 5 pounds of hay, with no grain except possibly a pound of oil meal or cottonseed meal. With fattening cattle, the typical ration is 25 pounds of silage, 4 pounds of hay, and all the corn they will eat, with perhaps a little oil meal or cottonseed meal in addition. In some cases very good gains have been obtained without any grain by feeding an average daily of 50 pounds of silage, 2 pounds of alfalfa or clover hay and 2 pounds of oil meal. Silage is ordinarily fed to sheep at the rate of 2 pounds per head daily. Moldy silage is a little more likely to cause trouble with sheep than with cattle. Silage may be fed to horses at the rate of 15 pounds per head daily, but moldy silage is even more dangerous with horses than with sheep. As a general rule, it should be remembered in feeding silage that it takes about 3 pounds of silage to equal in feeding value 1 pound of hay, and that for the best results with all kinds of livestock, silage should not completely take the place of hay, although it usually pays with cattle in the central part of the Corn Belt if silage takes the place of three-fourths of the hay in the ration.

Measuring and valuing silage.—To measure silage in a circular silo, square the diameter and multiply by .7854 and then by the depth of settled silage. This gives the number of cubic feet. If not much silage has been fed out allow 40 pounds to the cubic foot. In the bottom one-third of the silo, allow 43 pounds per cubic foot. A ton of average Corn Belt silage is worth the value of 6 bushels of corn plus 300 pounds of loose hay.

CHAPTER XI

RAISING SWEET CORN

Sweet Corn is extensively grown for canning purposes in many sections of the Corn Belt, especially in Iowa and Illinois. It takes about 1000 acres of sweet corn to maintain an efficient canning factory. Sweet corn is an early cash crop, that is usually contracted for at planting time; hence, the marketing of the crop is not a problem. Sweet corn fits in well before winter wheat in the rotation, making for some sections a better combination than field corn and oats. The stalks left in the field after snapping the sweet corn are a valuable feed, worth $3 or $4 an acre. In general, sweet corn is a profitable crop for many farmers located within four miles of a canning factory.

Choosing a variety.—The ordinary dent, flint and soft corns are usually referred to as field corn, although some of these types are occasionally used as roasting ears. Kernels of sweet corn are horny, wrinkled and translucent. The high sugar content of the kernel gives this type of corn its name and particular uses. Most sweet varieties are prolific and sucker greatly. As a rule, sweet corn requires a shorter season than field corn.

Distinct varieties of sweet corn were not well developed until the end of the nineteenth century. Now there are a great number of varieties, which are usually classified as to time of maturity. The following varieties are commonly grown in the Corn Belt for canning purposes:

1. Stowell's Evergreen—medium late, most prominent canning variety.
2. Narrow Grain—An unusually deep-kerneled, narrow-grained type of Evergreen which matures quite late.
3. Country Gentleman—late, good quality; yields less, but brings

higher price than Stowell's Evergreen; canners like it because the grains are narrow.

4. Golden Bantam—very early, small, yellow, tender; prospects of becoming a very important canning variety in northern sections.

Determining the right soil and climate.—Good corn land is as important for sweet corn as for field corn. For a description of corn soils and fertilizers, see Chapter VI. Sweet corn is not as hardy as the field corns, and is more easily injured by frosts or backward spring weather. In addition, hot weather makes the corn tough. Cool seasons make a tender corn. Otherwise, the general relation of climate to sweet corn is about the same as for field corn.

Sweet corn when harvested at the canning stage does not exhaust the soil fertility as do most farm crops. It is a well-recognized fact that the processes involved in the maturing and filling out of the seed make a heavy drain upon the fertility of the soil. Sweet corn is harvested before this stage is reached. At this stage, ears are 75 per cent water. As sold to the canning factory, the ears from an acre of sweet corn remove slightly more potash, 55 per cent as much nitrogen and 25 per cent as much phosphorus as the ears from an acre of field corn. Since potash is not as important as nitrogen and phosphorus under Corn Belt conditions, it may be seen that sweet corn is quite easy on the land.

Selecting the seed.—According to Erwin, it is customary for the canners in the Corn Belt to " renew the seed supply, commonly from the New England States, every year or at frequent intervals. This practice seems to be based upon three assumptions: First, that sweet corn when grown continuously under Corn Belt conditions loses in sugar; second, becomes starchy, and third, tough." However, Erwin's tests show that these assumptions are not always true, and that adapted home-grown seed should be used.

Cultural methods to use.—A well-prepared seed bed similar to the one for field corn should be made for sweet corn. The crop should not be planted until after field corn, for it is not so

vigorous and grows slowly in a cold, wet soil. From four to five kernels are planted in a hill. Planting operations and cultivation are just the same as for field corn.

Marketing and Canning

Harvesting and marketing methods to use.—Sweet corn is harvested much earlier than the field varieties. The harvest season is about a month in length, from the middle of August to the middle of September. Sweet corn is at its best for table use about eighteen days after the silks emerge. For canning factories, however, twenty-one days between silking and picking is about right. The ears are snapped with the husks on and delivered direct to the canning factory, and it is important that the corn be gathered at the right time. With the sweet corn crop there is no storage problem and no loss in shrinkage.

The customary yield on 40-bushel corn land is $2\frac{1}{2}$ tons of snapped corn to the acre. Prices for sweet corn vary greatly from year to year. Corn Belt canneries usually pay for a ton of the snapped corn delivered to the factory a price equivalent to 14 or 17 bushels of new corn. Of course, unusual weather, causing unusually cheap or unusually high dent corn prices, may vary this ratio, but one year with another these figures are about right for Evergreen corn. Ordinarily, the gross income from field corn and sweet corn grown on similar land is about the same. The higher value of sweet corn stalks, however, and the other incidental advantages make the real income from sweet corn usually greater than from dent corn.

Canning the corn.—Practically all the work of canning is done by machinery, from the time the corn is dumped on the scales until it is loaded on cars with labels attached. The corn is first husked, then the ears pass through a silker, and from there they go to the cutter. The cobs are ejected from the building, while the kernels pass on to the mixing vat, where salt, sugar and water are added in proper proportions. The corn then is fed into cans, which are capped and cooked in steam for an hour or

two. Labeling and boxing usually are not done until after the rush season, or until time for the corn to be put on the market. A ton of ordinary Evergreen sweet corn yields about 600 cans, or 25 cases. With prices as they have prevailed in recent years, with canned Iowa corn selling wholesale, per dozen, at $1, the canneries were selling the product of the average ton for about $50. Of this, about $15 represented the cost of the 600 cans. In addition, salt, sugar and other materials cost about $3, and labor amounted to perhaps $6. Overhead expenses were around $12.50 and farmers were paid $10 a ton for their corn. The retail price is usually 45 per cent above the wholesale. When Iowa sweet corn retails at $1.45 a dozen, the Iowa farmer is paid about 25 cents out of this $1.45. The grower of the sweet corn seems to be only one small factor in a highly complicated process.

It will be noted from Table XV that Iowa and Illinois lead in commercial sweet corn canning just as they do in the production of commercial field corn. Because of the rich soil and large level fields it is possible to produce sweet corn in Iowa and Illinois at a lower price per ton than it is elsewhere in the United States.

The finest quality sweet corn is grown in the New England states, especially in Maine and New Hampshire. Early strains of Golden Bantam are grown on rather small fields which are very heavily fertilized. The cost of production is heavy, but the price per ton is also high and as a result a number of farmers in the New England states have been able to make fairly good money producing Golden Bantam sweet corn for the canneries.

The bulk of the sweet corn in the United States will doubtless continue to be produced in the Corn Belt from the larger-eared, deeper-grained sorts of the Evergreen and Country Gentleman type.

Husk pile silage.—Husk pile silage compares favorably with ordinary field corn silage. It is a valuable by-product of the canning factory, that is usually sold or given to the growers for feed. This silage is made up of husks, tips of ears, and cobs, which are high in protein and starch. The cobs are not as val-

TABLE XV

SWEET CORN FOR MANUFACTURE: ACREAGE, YIELD PER ACRE AND PRICE PER TON *

State	Acreage			Yield per Acre			Price per Ton		
	1924	1925	1926	1924	1925	1926	1924	1925	1926
	Acres	Acres	Acres	Tons	Tons	Tons	$	$	$
Delaware	4,400	5,000	3,000	1.9	2.7	2.8	12.00	18.00	15.00
Illinois	50,560	70,650	58,280	1.7	2.4	2.5	13.58	14.29	14.23
Indiana	21,000	35,990	30,380	1.7	2.4	2.9	14.74	14.83	10.18
Iowa	55,500	70,720	50,480	1.5	2.7	3.0	9.55	11.14	10.25
Maine	13,390	15,630	13,940	2.7	2.9	3.1	29.10	29.76	28.72
Maryland	32,500	42,820	28,850	1.8	2.7	2.2	14.69	17.67	14.08
Michigan	11,000	13,630	11,080	1.2	2.5	2.0	14.76	14.30	12.54
Minnesota	21,000	30,540	24,450	2.5	2.1	3.0	9.46	10.28	9.93
Nebraska	7,000	8,880	6,970	1.8	2.2	2.7	9.18	10.94	10.07
New Hampshire	1,200	1,470	1,010	2.8	2.6	2.2	24.40	25.00	23.65
New York	26,000	31,350	27,420	1.8	2.3	2.2	19.59	20.74	18.24
Ohio	27,450	34,520	26,380	1.4	3.2	2.7	10.64	13.61	10.14
Pennsylvania	3,200	6,850	4,480	2.0	3.6	2.0	17.72	18.93	13.00
Vermont	2,500	2,620	2,370	2.8	2.6	2.4	20.00	19.94	21.30
Wisconsin	13,720	17,740	17,350	1.3	2.5	1.7	11.93	12.33	11.81
Other States	2,370	4,500	4,840	2.0	2.3	2.0	13.50	14.00	12.00
Total	302,790	393,910	311,640	1.7	2.6	2.6	14.17	15.04	13.17

* From Report of United States Department of Agriculture, Bureau of Agricultural Economics.

uable as the husks and refuse ear tips. Husk pile silage ferments in the pile where it is dumped at the factory, and it need not be placed in a silo.

Uses of sweet corn.—Most of the sweet corn grown on a field scale in the Corn Belt is sold to canning factories that are within hauling distance of the farms. Dried sweet corn is still used by farmers, and sweet corn on the ears in the "roasting stage" or "in the milk," is an important vegetable. A small amount is picked for table use. Although sweet corn yields less than field corn, a few farmers prefer it for hogging-down or sheeping-down. According to the Iowa station, "Sweet corn provides an early soiling crop. It may be harvested in early September before the field corn is sufficiently matured and at a time when green feed is usually scarce. Sweet corn silage has a very high value. The stalks are sweet, palatable, and contain less crude fiber and hence a higher percentage of digestible matter than field corn."

CHAPTER XII

RAISING POPCORN

The growing of popcorn on a field scale in the Corn Belt is a specialized and localized industry. Profit in popcorn growing depends largely on the grower's ability to produce popcorn of good quality, store his crop properly, and market it advantageously. In comparison to field corn, popcorn is more bother to raise, harder to get a stand, more difficult to keep clean, and more bother to gather and deliver. In addition, marketing difficulties and fluctuating prices make it an unprofitable crop for promiscuous planting.

Selecting the type of popcorn.—The three common types of popcorn are White Rice, Jap and Pearl. In the great popcorn district in Sac and Ida counties, Iowa, the White Rice and Jap are grown almost exclusively.

White rice.—The kernels are pointed at the crown. Ears are 7 or 8 inches long and carry twelve or fourteen rows of kernels. The stalks are usually 6 or 7 feet tall. It yields about 70 per cent as many pounds of ear corn per acre as ordinary dent corn grown on the same land. It is the outstanding popcorn of America, but the Jap is gradually replacing it to a considerable extent.

Jap.—The kernels are pointed like the White Rice, but are much narrower. The ears are only 2 or 3 inches long. They carry typically from twenty-four to thirty-six rows of grain. Kernels are deep but exceedingly narrow. The stalks are about 5 feet tall. It will yield about 70 per cent as many pounds per acre as the White Rice and about half as many pounds as ordinary dent corn on the same land. Because of the small ears, it

is difficult to husk. When huskers of dent corn are paid 4 or 5 cents a bushel (80 pounds of ear corn), it is customary to pay huskers of White Rice about 15 cents per hundred pounds of ear corn and huskers of Jap about 23 cents per hundred pounds of snapped corn.

Jap corn suckers less than most strains of White Rice, and the main tassel spike is shorter and thicker. Many of the stalks are somewhat hairy. Two or three ears per stalk are common.

Jap produces a more tender product on popping than the White Rice, and is much in demand on that account. Some call it Jap Hulless because it is so tender. It also increases

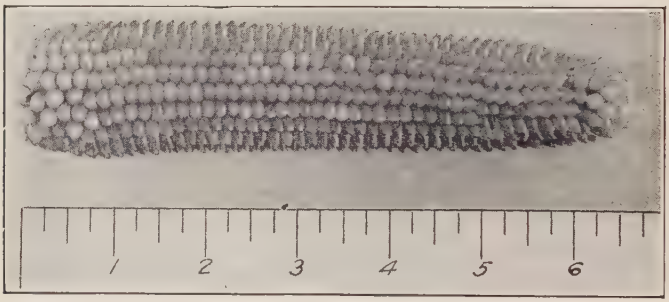


Fig. 58.—Typical ear of White Rice popcorn, which is grown commercially more than all other kinds put together.

more in bulk on popping than is the case with ordinary White Rice.

The market has normally paid from 40 to 100 per cent more for Jap popcorn per hundred pounds of snapped corn than for White Rice per hundred pounds of ear corn.

Pearl popcorn.—The kernels are rounded and shallow, and look like small flint kernels. The ears are about 8 inches long and carry eight to fourteen rows. The eating quality of Pearl popcorn is low as compared with the Jap. The large popped kernels of the eight-rowed variety are strung on strings and used as ornaments at Christmas-time. The three common Pearl varieties are White Pearl, Golden Queen and Eight-rowed.

Growing the crop.—Popcorn is grown in almost exactly the same way as ordinary dent corn. It should not be planted after June 1, because popcorn which is the least bit immature is worthless. An ordinary corn planter with special plates is used to plant popcorn. It may be either checked or drilled, but drilling is to be discouraged unless the land is exceptionally free from weeds. Five to six kernels are dropped in a hill, and often 3 feet 4-inch wire is used, so that the cross-rows are 40 inches apart and the planter rows 42 inches. Five to 6 pounds per acre of White Rice or 3.5 pounds of Jap rice give a good stand.

Cultivation is practically the same as that of the dent corn. However, the smaller plant makes the first cultivation a little more difficult. Three to four cultivations are the rule, and it is "laid by" at the same time or a little later than dent corn.

Popcorn ripens somewhat earlier than field corn, husking often beginning the last of September or the first of October. It should be fully mature before frost comes, as freezing injures the popping quality and greatly reduces its value on the market. The best quality of popcorn is obtained by allowing the ears to ripen fully on the standing stalks. Husking from the shock, while practiced in a limited way, is very poor practice. Formerly, popcorn was harvested exclusively by hand, but in late years the husking machine has come into favor as a means of getting the corn into the crib. Both methods have their good points. Three men operating a machine will crib as much corn as five men by hand. The husking machine is discussed in Chapter II. Forty inches of White Rice per day is a good day's picking for a man. It seems to take at least twice as much labor to husk White Rice popcorn as it does dent corn.

Marketing.—From 60 to 75 per cent of the entire crop is marketed before the first of January. Some is hauled directly from the field to the market. The crop is often contracted for before the seed is put into the ground. The contract price fluctuates greatly, but is usually around $2 per hundred pounds of White Rice ear corn and $2.50 to $3.00 per hundred pounds of Jap rice, when prospects are for dent corn selling for 50 cents

per bushel of ear corn (70 pounds) in December. Most of the popcorn cribbed on the farm is marketed shelled. Shrinkage, according to one authority, is about 30 per cent. Rat-proof cribs are often used, though rodents do less damage to popcorn than to dent corn.

Cribbing and shelling.—The Dickinson, Cracker-jack and Shotwell people, who buy the bulk of the commercial popcorn, have built large plants for the storage of popcorn. One plant in Sac county, Iowa, consists of four cribs with a capacity of 1,250,000 pounds each of ear corn, or a combined capacity of

FIG. 59.—Popcorn cribs along railroad tracks, owned by one of the big commercial concerns in Sac County, Iowa.

5,000,000 pounds; an elevator with a 350,000-pound shelled corn capacity, and five tanks with a capacity of 2,000,000 pounds of shelled corn.

Early in the summer, shelling starts in the big cribs and is kept up intermittently all summer, so that the cribs will be empty in time for the new crop. The sheller is built in as part of the plant, and endless belts convey the corn from the cribs to the sheller.

ADDITIONAL INFORMATION

Popcorn is grown in practically every state, but the main portion of the market supply comes from Sac and Ida counties, in Iowa, and Valley and Greeley counties, in Nebraska.

Iowa is the leading popcorn state. Ida and Sac counties normally grow over 10,000 acres annually. The following table gives popcorn acreage in these two counties for different years:

	1912	1919	1922	1923	1924	1925	1926	1927
Ida County...	5,412	11,411	2,996	6,330	6,510	8,370	6,522	5,112
Sac County...	8,408	14,722	5,160	10,492	10,710	13,770	14,420	8,630

Uses of popcorn.—Most of the popcorn is used as a confection. " Cracker-jack," " Checkers " and similar well-known delicacies are coated popcorn. In handling the commercial grades of popcorn, the wholesaler must figure on a waste of 7 to 25 per cent. This waste is made up of kernels that will not pop, kernels that are mixed with dent corn and dust or broken pieces of cob that the sheller did not clean cut. Considerable popcorn flour is used commercially.

Why it pops.—Popping is caused by explosion of moisture contained in the horny, hard, dense starch of the kernel when heat is applied. If there is more than 15 per cent moisture or less than 10 per cent, the popping is likely to be somewhat imperfect. New crop popcorn will ordinarily get down to 15 per cent moisture by December or even earlier if it is stored in the house. Popcorn stored in heated buildings often contains less than 10 per cent moisture, and therefore pops poorly. Pop-ability may be restored by placing the popcorn outdoors for a few days or by placing 2 pounds of the shelled corn in a two-quart fruit jar and adding 2 or 3 tablespoonfuls of water, closing the jar tightly and allowing it to stand for a few days. The result should be the absorption of enough moisture to result in the optimum 13 per cent content. Good rice popcorn containing 13 per cent moisture will increase in volume eighteen or twenty times; Jap Rice, twenty-five to thirty times, and the large grained eight-rowed types about fifteen times. Unless moisture

conditions are just right, the yields will be lowered with all of these types. Large increases in volume seem to be associated partly with a small kernel, partly with a deep, narrow kernel and partly with an exceedingly dense, hard starch with no soft starch whatever.

CHAPTER XIII

DEVELOPMENT AND PARTS OF THE CORN PLANT

The two steps in the development of the corn plant are first, germination, and second, growth. The essentials of these two steps in development are discussed in this chapter.

The Plant Development

Germination.—The four conditions necessary for seed to germinate are: (1) vitality, (2) moisture, (3) heat, and (4) oxygen.

Under favorable conditions, corn may retain its vitality for ten years but after the second year of storage the vigor of germination rapidly declines. As a practical proposition, seed corn should never be kept past the second year.

Moisture is necessary for seeds to germinate. Water readily penetrates and softens the seed coat of corn.

Corn requires a higher temperature to germinate than the small grains. It is a crop which germinates best under higher temperatures than usually prevail in May. Pammel, of the Iowa station, gives the following temperatures for the germination of corn: Minimum, 49.9° F.; maximum, 134.8° F.; optimum, 91.4° F. Cold-resistant strains of corn have been developed which will germinate when the temperature is as low as 43° F.

Oxygen is found in the seed, but not enough for germination. One of the reasons that corn does not germinate well on poorly drained soils is that the excess water in the soil excludes oxygen.

Growth.—Growth is cellular development. During early

development, growth takes place in all parts at the same time, and after the first three weeks of growth all parts of the plant are formed. The five essentials for the growth of the corn plant are: (1) vigor, (2) water, (3) light, (4) heat, and (5) plant food.

Vigor.—The plant must have inborn vigor. A seed may sprout, but if the seedling does not have strength a normal plant will not be obtained.

Water.—Corn requires large quantities of water to carry plant food and to keep it from wilting. Kiesselbach of Nebraska found that the rapidity of transpiration of corn varies directly with the temperature and the leaf area. A well-grown corn plant on a hot day in late July will transpire 5 to 10 pounds of water. This means that an acre of corn plants at this time of year is pumping up water from below and throwing it into the atmosphere at the rate of 18 tons daily, or 720 tons of water per acre, equivalent to 7 inches of rainfall, during July and August when the corn is most active.

Light.—Light furnishes the power which all green plants require. The process by which green plants take sunlight and store up its power is known as photosynthesis (light-building). In photosynthesis the carbon dioxide of the air enters the leaves through stomata (little holes) and is there combined by the power of the sunlight with water to make formaldehyde and later starch. Starch is literally imprisoned sunshine. Of all green plants, corn is one of the most efficient in capturing sunlight in large quantities and storing it away in the form of starch.

Heat.—Corn requires a large amount of heat for development. In a Pennsylvania experiment, it was found that during the twenty-two days preceding tasseling, those days with a mean temperature of less than 70° F. usually resulted in a growth of 3 to $3\frac{1}{2}$ inches in twenty-four hours, whereas those days with a mean temperature of 75° or more resulted in a growth of 5 to $5\frac{1}{2}$ inches in twenty-four hours. When the temperature in the daytime exceeded 85°, further increases did not seem to result in greater growth, probably because of moisture shortage.

Plant foods.—A fifth essential for growth is plant food. Corn requires the following chemical elements: Carbon (C), hydrogen (H), oxygen (O), phosphorus (P), potassium (K), nitrogen (N), sulphur (S), calcium (Ca), iron (Fe), magnesium (Mg). The expression, " C.HOPK(i)NS CaFe Mg (Mighty Good) " is a reminder of the essential chemical elements.

Oxygen, carbon and hydrogen are furnished by air and water, whereas the other elements are minerals in the soil. About 97 per cent of the corn kernel comes from the air and only 3 per cent from the soil. Each element is a specialist in its own field, and should it become deficient can not be replaced by another.

Oxygen is the most abundant element. It readily forms compounds with practically all other elements and constitutes about one-half of all known matter. It enters the plant in the compound, CO_2, a gas, and H_2O, water, where it is further changed by sunlight to build up the carbohydrates and proteins. The corn kernel is about 46 per cent oxygen.

Carbon is closely associated with plant life. It enters the leaves of the plant in the form of CO_2, where it is combined by sunlight with water brought up from the roots to form sugar, starches and the like. Carbon composes 45 per cent of the corn kernel.

Hydrogen is the third most abundant element in the corn kernel. It makes up 6.4 per cent of the corn kernel. Water is the one important source of hydrogen for plant growth. This element is combined by sunlight with carbon and oxygen to form the various carbohydrates and proteins within the plant.

Nitrogen is one of the most important and possibly the least appreciated elements. It forms one-sixth of the protein in plants, the formation of which would be stopped without it. Nitrogen:

1. Stimulates growth of foliage.
2. Imparts a deeper green color to foliage.
3. Delays the maturing process.
4. Controls the amount of other plant foods used.

About 1.5 per cent of the corn kernel is nitrogen.

Sulphur is an important constituent of both protein and protoplasm. In most corn soils there is a great abundance of sulphur. About 0.2 per cent of the corn kernel is sulphur.

Phosphorus is found in every cell of every plant, but it is especially abundant in the seed. It is of great value because it:

1. Causes rapid germination of seed and vigorous, early root growth.
2. Causes early ripening.
3. Causes greater formation of seed in proportion to stem.
4. Is essential to protoplasm.

About 0.3 per cent of the corn kernel is phosphorus.

Potassium plays an important rôle in the development of plant life. It seems to:

1. Encourage carbohydrate formation.
2. Aid in transference of starch.
3. Aid the plant in resisting fungus disease.

About 0.3 per cent of the corn kernel is potassium.

Calcium, which is fundamental both to plant and animal nutrition:

1. Aids in the development of root hairs.
2. Aids in the transportation of starch.
3. Neutralizes plant acids.
4. Has a strengthening effect on cell walls.

The corn kernel contains less than 0.1 per cent of calcium.

Calcium, phosphorus and potassium, when found in abundance in the soil, keep the corn plants from absorbing undue amounts of aluminum and iron and thus predisposing themselves to diseased joints, fired leaves and root rot.

Magnesium is found more particularly in the seed of plants. In this respect, it is the opposite of calcium. Practically all soils contain sufficient magnesium for plant growth. About 0.14 per cent of the corn kernel is magnesium.

Iron is second to oxygen in abundance in the earth's crust. It is never a limiting factor in production, as plants use only a

small amount of it. Nevertheless, iron is essential to chlorophyll production. By withholding iron from plants, no chlorophyll will develop, and consequently the plant makes no natural growth. Only small traces of iron are found in the corn kernel. Iron may act as a poison to corn, especially on tight clay soils which are low in phosphorus, calcium and available potash.

Of these ten essential elements, there are two, phosphorus and calcium (lime) which must be purchased and added to the soils of the Corn Belt to keep them productive. The other eight elements are usually present in abundance already or can be maintained through certain natural processes.

Roots

Corn, like other grasses, has a fibrous root system. The three types of corn roots are: (1) temporary, (2) permanent, and (3) brace roots.

The temporary root system is composed of the roots which are pushed downward from the tip of the kernel when it first sprouts. During the first two or three weeks after germination the temporary roots furnish most of the food which the young plant obtains from the soil. Later on, these roots either rot away from the plant or become unimportant except in the case of Hopi corn, which seems to rely on the temporary roots to bring up moisture from the deeper layers of the soil.

If the young corn plant, two or three weeks after germination, is dug up, it will be noted that between the kernel and the green stem above ground is a slender white stem. This is known as the mesocotyl. In the case of corn planted 1 inch deep, the mesocotyl is about 1 inch long, whereas in the case of corn planted 12 inches deep (Hopi corn is often planted this deep), the mesocotyl is 12 inches long. The temporary roots start from below the mesocotyl and go downward, whereas the permanent roots start from just above the mesocotyl.

Permanent roots.—The first two, three or even four nodes of the mature corn plant are separated by very short inter-nodes and are just below the surface of the ground. It is from these nodes just below the surface of the ground that the permanent

FIG. 60.—Illustrating how depth of planting influences length of mesocotyl and why the permanent roots (*p*) start just below the surface of the ground, no matter how deep the kernel is planted. The temporary roots (*t*) lose their importance after the permanent roots are well established, except possibly in the case of Hopi corn.

roots start out laterally from the nodes and then go downward to a depth of as great as 5 or 6 feet. The large, strong permanent roots are concentrated within a foot or two of the plant and only the small, fibrous roots reach the greater depth.

FIG. 61.—The root system of corn is much more extensive than most people suspect. This picture shows only a part of the roots. The great mass of the fine roots is lost on digging.

Courtesy of Iowa Station.

FIG. 62.—Brace roots.

Brace roots.—Brace roots differ from the permanent roots in that they come from the first two or three nodes above ground. In "down" corn or certain tropical varieties the brace roots may come out from nodes as high up as the fifth or sixth. Brace roots from the first node or two above ground are of very real help in maintaining an upright corn plant, but it is doubtful if brace roots from the higher nodes serve any useful purpose. Funk, of Illinois, says they are associated with diseased corn.

The roots of the corn plant:

1. Support and anchor the stalk.
2. Absorb plant food (soluble salts and water).
3. Excrete organic substances (such as carbon dioxide, and organic acids).
4. Render plant food soluble by action of the excretions.

Root growth is increased when the following conditions are present:

1. Large supply of oxygen.
2. Favorable temperature.
3. Plenty of moisture.
4. Good soil tilth.
5. Abundant available plant food.

The Corn Plant above Ground

Stalks.—The stalks of corn vary in height from $1\frac{1}{2}$ to about 30 feet. Some of the small, early popcorns will develop ears when only $1\frac{1}{2}$ feet high. Silage corns often make a growth of 15 feet.

The stalk is made up of nodes or joints, usually eight to twenty in number; the average number is about fourteen. In typical dent varieties of the central Corn Belt, the eighth node as a rule bears the ear. The node is the origin of all lateral outgrowths, such as roots, branches, leaves and ears. The portion of the stalk between the nodes is called the inter-node. The longer inter-nodes are toward the top and the shorter toward

the base. The stem of each inter-node is hollow on one side and it is on this hollow side that the leaf comes out. From the lower nodes on this hollow side there usually develops a small bud which does not amount to much except in the cases of the nodes which bear ears.

In cross-section, the stalk is made up of four main parts:

1. The epidermis, a thin transparent tissue, covers the outer part of the stalk. It is impervious to moisture and protects the stalk from insects and disease.

2. The stem wall is just beneath the epidermis. It is a woody layer, the hard, stiff portion of the stalk, made up of large numbers of fibro-vascular bundles, closely packed together. These bundles, stiffened by silica deposits, make the stem wall the " backbone " of the plant.

3. The center cavity of the stalk is filled with pith. It is a soft, spongy mass of tissue and serves as a storehouse for moisture and food. The fibro-vascular bundles in the pith are separated by large masses of pith.

4. The fibro-vascular bundles are channels for the transportation of plant food. They are found mostly in the woody stem wall and extend from the roots up through the stalk to the leaves and ears. They carry mineral plant food from the roots to the leaves and manufactured plant food to the ears and stalk. A little food is manufactured in the stem as well as the leaves.

Length growth takes place just above the nodes, and at the end of the stalk. The growth may be likened to a telescope. As a telescope unfolds, so does the cornstalk unfold. Therefore, the statement that we can "see corn grow over-night," is often made. Diameter growth takes place from the inside and not by added layers as in a tree. This type of diameter growth is called endogeneous.

Suckers.—Suckers, or tillers, are branches which come from the nodes just at or just beneath the surface of the ground. The tendency to sucker is influenced by the variety, soil conditions, rate and method of planting. A large amount of available plant food will produce more suckers than soil in poor condition. Plentiful moisture increases the number of suckers.

Corn planted one kernel to the hill will send out more suckers than when planted at the rate of five kernels. Suckers have

their own root system and often bear ears. However, the ears as a rule are inferior to those upon the main stalk, often being borne on the tassel. It does not pay to pull off the suckers. At the Nebraska station, pulling off suckers was found to reduce the yield greatly.

Leaves.—The leaves on a corn plant are arranged alternately, conceal the grooved sides of the stalk, and are usually twelve to eighteen in number. The wavy margin, the result of the outside growing faster than the midrib, adds surface and flexibility to the leaf. The corn leaf is made up of three parts:

1. Leaf sheath. It comes from the node, and clasps or surrounds the stalk.
2. Blade, often incorrectly called the leaf. It is composed of the mid-rib, veins (parallel to mid-rib) and intracellular tissue.
3. Ligule, located at the hinge between the sheath and the blade. It is a collar which prevents water, dirt and insects from running down the sheath and stalk. At either end of the ligule is situated the auricle, or lobe-like portion. It is the light-green, wavy, triangular portion of the blade. It turns the water down the stalk onto the leaf below.

There are large numbers of small openings in the leaves known as stomata, through which carbon dioxide of the air passes into the interior of the leaf. The leaves, by means of their chlorophyll or green coloring matter, are able to use the energy of the sunlight to combine this carbon dioxide with water and ultimately to form sugars and starches. The leaves, besides manufacturing food, serve a useful purpose in evaporating surplus moisture. The leaves of an ordinary corn plant will evaporate on a hot July day from 5 to 10 pounds of water.

Flowers.—The male and female flowers of corn are located in spikelets on different parts of the same plant. This flower arrangement makes cross-pollination and fertilization the general rule in corn. It is estimated that not more than 5 per cent of corn grown under field conditions is selfed (pollen falls on silk and fertilizes ovule of the same plant). Kiesselbach found less than 1 per cent of self-fertilization under ordinary Nebraska conditions.

The male flowers are located in spikelets on the tassel of the plant. Each spikelet contains two flowers and each flower has three anthers, which contain the golden colored pollen. There are about 2000 pollen grains in each anther, and there are about 7000 anthers in each tassel. Therefore, each tassel may furnish about 15,000,000 pollen grains. This number is far in excess of the pollen required, because only one pollen grain is needed for the development of each kernel, and an ear requires only from 800 to 1000 pollen grains to bring about the development of all possible kernels. There are therefore 20,000 pollen grains produced for each kernel. The pollen is carried by the wind, and occasionally pollen may be blown half a mile. There is, however, much less mixture between fields than is commonly thought. Pollen ordinarily retains its vitality for about twenty-four hours. It may be killed in a few hours by heat and drouth.

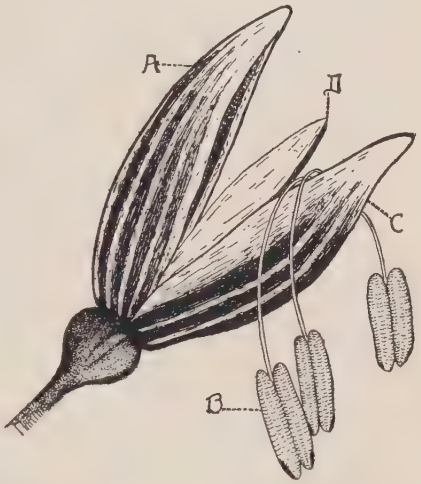


FIG. 63.—Staminate or male spikelet as borne by the corn tassel. (*a*) Upper flower, which has not yet opened enough to show anthers; (*b*) anther of the lower flower; (*c*) empty glume; (*d*) palea.

The tassel, as a rule, emerges before the silks do, and so pollen is available from one to three days before it is needed. Kiesselbach says: "Extensive observations have shown that in general the pollinating period of the tassel materially overlaps the silking period. Self-pollination might occur extensively were it not for the overwhelming preponderance of foreign pollen scattered promiscuously through the air."

The female flowers are located in pairs on the cob. Only one flower of each pair develops. An exception is the Country Gentleman variety of sweet corn, in which both flowers develop. An average ear of corn will have about 800 developed female flowers. Each of the flowers sends out a silk (style), and it takes from two to four days to send out all the silks. The ker-

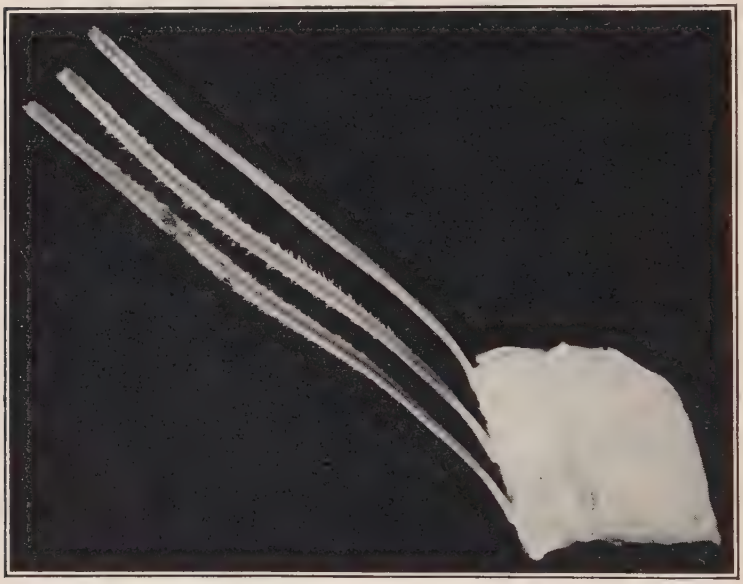


Fig. 64.—Illustrating how each unfertilized ovule on the young shoot has a silk (style) growing from it.

nels near the butt end of the ear send out their silks first. The end (stigma) as well as the surface of the silk is hairy and mucilaginous, to aid in catching the pollen grains. These silks are receptive to pollen before they emerge from the husk, and if they are not fertilized, they remain receptive for about two weeks.

Fertilization.—Kiesselbach says: "Every kernel has its own silk and must be fertilized separately. In the process of

fertilization, pollen falling on the silk germinates and grows a pollen tube through the silk to the kernel, to which it conducts the two sperm nuclei. One of these nuclei fuses with the egg nucleus to form the initial embryo nucleus (true fertilization), and the other with the two polar nuclei, forming the initial endosperm nucleus (causing xenia, see Chapter XVI). This entire process has been found to be completed within approximately twenty-four hours' time. Fertilization is reflected in the discoloration and drying of the silks in from forty-two to seventy-two hours after pollination."

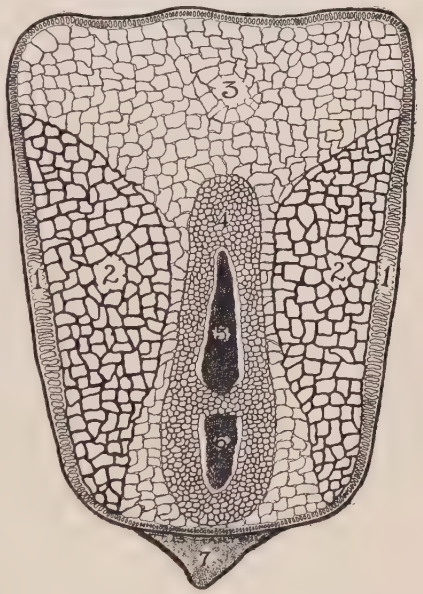


FIG. 65.—Typical kernel of dent corn. (1) Aleurone layer, which is colorless and almost impossible to detect with the naked eye, except in blue and a rare type of red corn; (2) horny or hard starch, which is colorless except in yellow corn; (3) soft starch, which is white in all colors of corn; (4), (5) and (6) together are the germ, (4) being the scutellum, (5) the plumule and (6) the radicle; (7) tip cap.

CORN EARS AND KERNELS

Ear compared with sucker.—The ear, including the shank and husks, may be likened to a branch or sucker of the main stalk. The nodes of the shank occasionally bear several small ears in addition to the main ear. Each husk represents the leaf sheath, and the streamer often found toward the top of the husk is comparable to the leaf blade. The cob is analogous to the tassel, in that it is a central spike which bears flowers. How-

ever, except in the case of freak ears, the cob has no lateral branches.

As a rule, Corn Belt varieties mature but one good ear of corn upon one stalk. Prolific varieties mature several ears upon one stalk.

Kernel.—The kernel is ripe in the ordinary season about fifty days after fertilization. Twenty days after fertilization the kernel is ripe enough to germinate, although it has only reached the milk stage by this time.

Stages of ripening are:

Milk stage—starch in the form of a fluid (about twenty days after fertilization).

Soft dough—starch soft and cheesy (about thirty-five days after fertilization).

Hard dough—starch hard and firm (about forty-two days after fertilization).

Glazed—(about fifty days after fertilization).

Ripe (about sixty days after fertilization).

The kernel may be divided into six parts:

1. Hull—the thin covering which encloses the entire grain. The hull is nearly colorless in commercial varieties except in red and calico corn.

2. Aleurone layer—a thin layer just beneath the hull. This layer is colorless and difficult to distinguish except in blue corn and a rare dull-red type. The red aleurone type is never grown commercially.

3. Soft starch—large, loose starch cells that occupy the crown and often the back and a part of the germ end of the kernel. It is often called white starch. In soft or flour corn, nearly all the kernel except the germ is soft starch.

4. Hard starch—small, compact starch cells and protein bodies occupying the sides and back of the kernel. This starch is translucent, whereas soft starch is opaque. In flint corn nearly all of the kernel except the germ is hard starch. The color of yellow corn is found solely in the hard starch, which means that yellow flint varieties are usually far deeper in color than either the soft or dent varieties. The hard and soft starch together make up what is commonly called the endosperm.

5. Germ—oily portion occupying most of the front side of the kernel. Composed of three parts, plumule, radicle and scutellum (or cotyledon). The plumule develops into the stem sprout and permanent roots. The

radicle develops into the temporary roots. The scutellum absorbs, changes and transfers plant food for the seedling.

6. Tip cap—affords attachment of the kernel to the cob and protection to the germ. It is usually retained by the kernel in shelling. When broken off, it exposes the black covering of the germ. This covering is natural and not an unsoundness. Botanically, the tip cap is a bract which in the ancestors of corn almost completely enclosed the kernel.

CHAPTER XIV

CLASSIFICATION OF CORN

Corn is a summer annual which belongs to the grass family. Such other common farm crops as wheat, oats, barley, rye and sorghum belong to the same family. Incorrectly, flax and buckwheat are often called grasses. Botanists classify the corn plant as follows:

Botanical Division	Name	Characteristics
Family	Gramineae	Fibrous root system leaves alternate, parallel veins in leaves, split leaf sheath, ligule, stems cylindrical with solid nodes.
Tribe	Tripsaceae (maydeae)	Male and female flowers in separate places on the same plant.
Genus	Zea	Grain borne on a lateral cob.

Besides zea (corn), there are three other common genera belonging to the tribe Tripsaceae—Euchlaena (teosinte), Tripsacum (gama grass), and Coix (Job's tears). Teosinte and gama grass are described in Chapter XVIII. Teosinte will cross with corn, but as yet there have been no successful crosses of either corn or teosinte with gama grass or Job's tears. Job's tears is an ornamental garden plant. Large-growing, soft-shelled forms of Job's tears are cultivated as a grain crop in the Philippines and other tropical eastern countries.

There are several other genera belonging to Tribe Tripsaceae, which are found in India, but which seem as yet to be of no practical importance. From a strictly botanical point of view, there are no clear-cut species of the genus *Zea*. Before

the discovery of Mendel's law and its application to the genetics of corn, many distinct species of *Zea* were recognized. To-day most of these so-called species are looked on merely as interesting freaks which behave as Mendelian dominants or Mendelian recessives.

On the basis of kernel texture there are four common groups of zea (corn):

1. Dent
2. Flint.
3. Sweet.
4. Soft.

Dent Corn

Dent corn is characterized by a depression in the crown of the kernel. This denting is caused by the unequal shrinkage of the hard starch found on the sides of the kernel and the soft starch which composes the crown. The character of the indentation varies all the way from a shallow dimple through a crumpled crease to a thin beak or hook. This last kind of indentation is characteristic of those dents with the highest percentage of soft starch toward the crown. Dent corn varies in color and in size and shape of ear. There is also a great variation in size and shape of kernel. Some ears of dent corn bear kernels of the extreme shoe-peg type, very narrow and deep. Other ears of dent corn bear kernels of the square type, very wide and shallow. In between are all gradations of kernel type.

The great diversity of type sketched in the foregoing, together with historical and genetic evidence, indicates that dent corn is not in any sense a species, but a conglomerate mixture. This mixture seems to have resulted from both accidental and intentional crossing of the large flint type (recognized as a distinct sort in the early part of the nineteenth century) with the gourd-seed, which seems to have been a late-maturing, rank-stalked type, bearing an ear with 22 to 36 rows of rough, deep, very soft, shoe-peg kernels. The ears were rather short, small-cobbed and very thick because of the great depth of grain. Some people have looked on the gourd-seed as being synonymous with

dent corn. That this is not true is indicated by the testimony of farmers who grew both dents and gourd-seeds. For instance, one farmer who grew both wrote:

" Gourd-seed is a large, rough, soft corn. It is later and has larger stalks and ears than the other varieties. It lacks the flintiness and weight for the same bulk as the others have. In

FIG. 66.—Relatives of corn. At left, Job's tears, showing female flower below and male flowers above. At right, gama grass, with female tassels in lower part of tassel and male flowers in upper part. (*a*) female flower (*enlarged*); (*b*) male flower (*enlarged*).

comparison with dent of my own raising, in feeding hogs, I thought it took about one and one-fourth bushels to go as far as one of my own corn. But cattle in particular will eat it more readily, as it is not so hard to masticate."

Mr. John Lorain, in his " Practice of Husbandry," published in 1825, refers to the common practice of mixing gourd-seed with other varieties:

" So prevalent are mixtures that I have never examined a

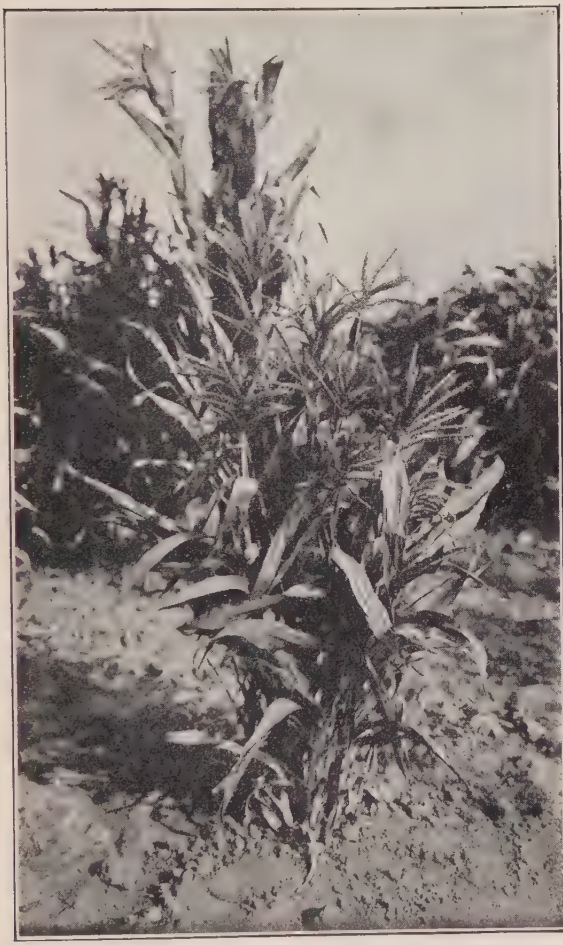


FIG. 67.—Teosinte-corn hybrid plant produced by a single kernel. Note large numbers of suckers and branches which bear tassels. A plant of this sort will often produce forty ears, but each ear carries only ten or fifteen kernels.

field of corn (where great care had not been taken to select the seed) which did not exhibit evident traces of all the corn in general use for field planting, with many others that are not used for this purpose. None can be longer nor more readily traced than the gourd-seed.

" The quantity of the gourd-seed mixed with the flinty yellow corns, may be determined, so as to answer the farmer's purpose. When the proportion of the former greatly predominates, the grains are pale, very long and narrow, and the outside ends of them are so flat (beaked) that but little of the indenture is seen. As the portion of the gourd-seed decreases in the mixture, the grains shorten, become wider, and their outside ends grow thicker. The indentures also become larger and rounder, until the harder corns get the ascendancy. After this, the outside ends of the grain become thicker and more circular. They also grow wider, and the fluted appearance between the rows increases. The indentures also decrease in size until they disappear, and the yellow, flinty variety is formed, but, as I believe, not so fully but that the latent remains will forever subject it to more or less change. It is more difficult to determine the quantity of big and little yellow flints, which may happen to be mixed with the gourd-seed, and at the same time with each other. The soft, open texture of the gourd-seed renders it unfit for exportation, unless it be kiln-dried."

Lorain previous to 1825, stated that true gourd-seed is white:

" It is invariably white, unless it has been mixed with the yellow flinty corns. Then it is called the yellow gourd-seed, and too many farmers consider it and most other mixtures original corns. I have often heard of original yellow gourd-seed corn, but after taking much trouble to investigate the fact, could never find anything more than a mixture. If there be an original yellow gourd-seed corn, it has eluded my very attentive inquiry from the Atlantic to our most remote western settlements."

Lorain also says that much of the corn which passes for white gourd-seed has been mixed with white flint.

Peter A. Brown, LL.D., writing a paper on corn for the Chester county, Pennsylvania, Cabinet of Natural Science, in 1837, refers to true gourd-seed as carrying twenty-four or more rows of kernels. He looked on ears carrying fourteen to twenty-two rows of kernels as mixtures of flint and gourd-seed. No reference is made to dent corn, although he lists thirty-five different types, seven of which he states were originated by

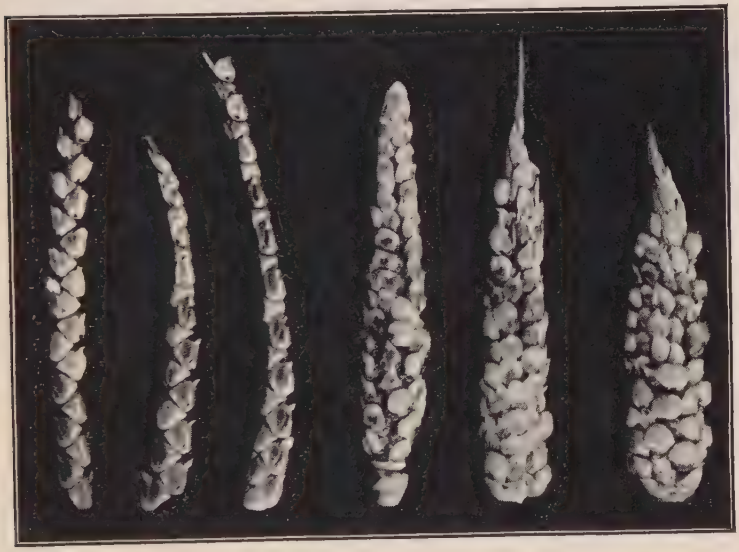


FIG. 68.—Teosinte on left contrasted with crosses of teosinte and corn on right.

mixing gourd-seed and flint. He mentions the King Philip as mixing especially well with gourd-seed.

According to the twelfth Smithsonian Institute report, the Mound-builders of Arkansas grew a type of corn which is "judged to be the variety known in the South as the gourd-seed corn."

Beverly, in his history of Virginia, written in 1705, states that the Indians grew a late flint and a late dent. "The other

has a larger grain and looks shriveled, with a dent on the back of the grain as if it had never come to perfection; and this they call She corn. This is esteemed by the planters, as the best for increase, and is universally chosen by them for planting; yet I can't see but this also produces the flint corn, accidentally among the other." Evidently there was some crossing of flint and gourd-seed to produce dent corn long before the time of John Lorain.

The genetic evidence in favor of the hypothesis that the typical dent varieties grown in the Corn Belt are a cross of the flint and gourd-seed corns consists in the ease with which inbreed-

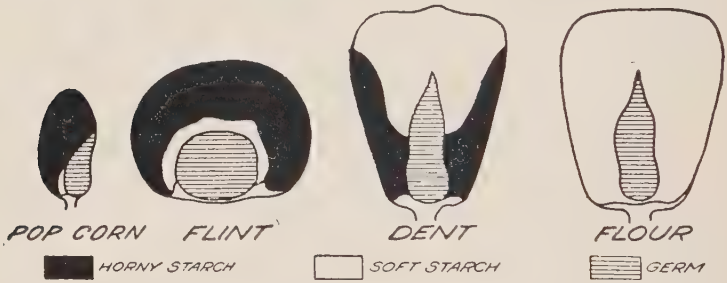


FIG. 69.—Diagram from U. S. Department of Agriculture, illustrating differences in kernel texture of different types ranging from flour corn to popcorn.

ing isolates out types which are practically pure flints. All of the experimenters who have done any extensive work in the inbreeding of dent corn have isolated strains of almost pure flint appearance. A few have also isolated narrow-grained, many-rowed, rough, starchy types which may be somewhat similar to the original Virginia gourd-seed as described by John Lorain. The gourd-seed type, however, does not stand up well under inbreeding unless there is at least some mixture of flint characteristics. Gourd-seed types, because of their lateness and susceptibility to disease, have thus far been difficult to isolate in their pure inbred form.

Of course, it is recognized that there may have been many other sorts mixed in forming the modern dent corn, but it is believed that the chief characteristics of dent corn as it is known in the Corn Belt to-day are due to the large flint and the gourd-seed.

Modern dents seem to contain varying percentages of flint and gourd-seed blood. Johnson County White appears to contain a high percentage of gourd-seed, whereas Northwestern Dent is unquestionably more than one-half flint. Reid Yellow Dent was formed by crossing the Gordon Hopkins corn of southern Ohio with the Little Yellow of Illinois. The southern Ohio corn of one hundred years ago presumably came largely to Ohio by way of Kentucky and Virginia, and it is likely that the late maturing Gordon Hopkins corn was rich in the blood of Virginia Gourd-seed. Little Yellow was a term often used to describe an early flint corn, and it is probable that Reid Yellow Dent was produced by selection by James Reid, following on the crossing by his father, Robert Reid, of a flint and gourd-seed type. At any rate, it is unusually easy to-day to isolate flint types out of all types of Reid except those which have been bred for the rough show type.

The hybrid heredity of dent corn and the consequent variability and possibility of securing unproductive as well as productive mixtures indicate that intelligent selection is probably more necessary with dent corn than with purer types.

Dent corn typically contains about 10 per cent protein, 68 per cent nitrogen-free extract, and 4.8 per cent fat. It is 1 to 2 per cent poorer in protein and 1 to 2 per cent richer in nitrogen-free extract than flint corn of the same moisture content. Shelled dent corn typically weighs 53 or 54 pounds per bushel, whereas shelled corn of the small seeded flints may weigh 60 pounds per bushel, and the flour corns may weigh only 50 pounds.

Flint Corn

Flint corn differs from dent corn in that it contains practically no soft starch; therefore, no indentation is formed. Most flints sucker profusely, and usually bear more than one ear per plant. Flint corns are good yielders and furnish excellent fodder. The corn meal made from flint corn is of superior quality. Most yellow flints are a much deeper yellow than yellow dents.

The four common classes of flint varieties are: (1) early flints, (2) medium flints, (3) tropical flints, and (4) popcorn.

The early flints are the earliest varieties of corn grown in the United States. They grow only 3 or 4 feet high, and bear the ear within a few inches of the ground. The color is variable, and the ear 6 to 7 inches long and usually carrying eight rows. This type is adapted to short seasons, high altitudes and dry conditions. Representative varieties are Gehu, Dakota White and Early Indian. Most of these early flints were developed by the Indians of the northwest with but very little improvement by the white man during the past thirty years.

The medium flint class consists principally of varieties that originated in New England and the Middle-Atlantic states. They grow from 5 to 7 feet in height, but are finer stalked than the dent varieties. They vary greatly in size and color of ear and in length of maturity. Most of them are eight-rowed. Because of their fine stalks and numerous leaves, they make an excellent quality of fodder and silage. Representative varieties are Longfellow, King Philip, Smut Nose and Mercer. Both the early and medium flints sucker considerably and carry many streamers on their husks.

The tropical flints are not well known in the United States. Presumably, Columbus found tropical flints growing on the West India islands and introduced them to Europe. Many of the common flints of Italy, the Balkan States and Argentina seem to be tropical flints. The tropical flints, as modified by selection in these countries, require about 120 days to mature. Many of them do not sucker. The kernels usually are narrower

and deeper than with the medium class of flints. Oftentimes the ears carry twelve, fourteen, or even sixteen rows.

Popçorn differs from the other flints in that it contains an even higher percentage of hard starch, the kernels are usually much smaller and the hull, in proportion to the size of kernel, is tougher and thicker. Because of these characteristics, the kernel, when heated, has the ability to pop better than the other flints. Popcorn is discussed in Chapter XII.

While there is great variability among all four classes of flints, just described, there is reason to think that they are more uniform in their characteristics than the dents.

Sweet Corn

Sweet corns may be of the dent type (Evergreen) or the flint type (Golden Bantam), and also of soft corn types. Sweet corn, therefore, has the possibility of being one of the most variable of all corn types. The only distinguishing characteristics of sweet corn are wrinkled kernels and translucent, hard starch, which does not mature normally, apparently remaining in the sugar stage much longer than is the case with ordinary corn. Sweet corn contains a much higher percentage of fat and protein than dent corn.

Soft Corn

Soft varieties of corn are grown only to a very limited extent. They are also known as "squaw" corn and "flour" corn. Soft corn is usually similar to flint corn in plant and ear characters, but differs in that the kernels are composed largely of soft starch instead of hard starch. Like flint corn, it has no dent (sometimes there is a slight dent in Hopi Indian corn). The horny starch in soft corn is such a very thin shell at the sides of the kernel that it is impossible for any strain of this corn to be deep yellow in color (the yellow color of corn is found only in the horny starch).

Strains of soft corn are Brazilian Flour, Hopi and the Blue Flour of the Nebraska and Dakota Indians.

Other Types

Kernel texture, while convenient for practical purposes, is only one basis of classifying corn. Geneticists have studied hundreds of distinct types which the botanists of a generation ago would have dignified with Latin names as distinct species. Some of these types are:

1. Pod corn—each kernel enclosed by a husk as well as the entire ear.
2. Brachytic corn—short-jointed corn which is normal in every respect except that the joints are only half the normal length. There is the usual number of leaves.
3. Purple-leaved corn—the leaves and husks are a deep, beautiful purple.
4. Japonica, or striped-leaved corn.
5. Hairy corn—hairs on the stems and leaves.
6. Ramosa corn—ear a round cluster of kernels without a true cob. (Discovered at the Illinois station.)
7. Corn bearing ears with lateral branches at the base of the cob.
8. Tassel ear corn—ears borne on tassels.
9. Waxy corn—logically, this should be included as a fifth member of the classification on kernel texture. The carbohydrates of the kernel are stored in the form of dextrin, instead of as starch. It is not shriveled, however, like sweet corn.
10. Starchy sweet corn—like waxy corn, this logically should be included with the classification on basis of kernel texture. The upper part of the kernels is translucent and horny like sweet corn, and the lower part is starchy. This corn is grown by certain Mexican and Peruvian Indians.

There are many more rather freakish types of this sort which have as legitimate claim, from a botanical point of view, to be known as species of Zea as do dent corn, flint corn, sweet corn and soft corn. From a practical point of view, however, this classification into four groups, on the basis of kernel texture, seems best.

CHAPTER XV

VARIETIES OF CORN

Although there may be a thousand varieties of strains of corn, a few leading ones make up a large percentage of the corn grown. A few of the leading varieties in different sections of the Corn Belt are:

Section of Corn Belt	Leading Varieties
Northern	Silver King, Minnesota No. 13, Northwestern Dent, Wimple, Golden Glow.
Central	Reid Yellow Dent, Silvermine, Boone County White, Leaming.
Eastern	Boone County White, Reid Yellow Dent, Johnson County White, Leaming, Funk Yellow Dent.
Western	Reid Yellow Dent, Silvermine, Hogue Yellow Dent, Freed White Dent, Calico.
Southern	Reid Yellow Dent, Boone County White Dent, St. Charles White, Kansas Sunflower.

Reid Yellow Dent

Reid Yellow Dent was originated by an accidental cross between a rather late, light-reddish colored corn and a small, early yellow corn. Robert Reid, the originator, brought the reddish colored corn, known as Gordon Hopkins corn, to Illinois from Brown county, Ohio, in 1846. Because of a poor stand in 1847, a small yellow corn, probably a flinty type, was used in replanting the missing hills, and so the cross occurred. James L. Reid, a son of Robert Reid, improved the hybrid by selection, his best work being done from 1870 to 1900. He won a prize with it at the World's Fair in 1893, and as a result it soon became widely distributed.

Standard ears of this variety are 9 to 10 inches long and 7 to $7\frac{1}{2}$ inches in circumference, for the central Corn Belt, but vary somewhat with the section of the Corn Belt in which they are grown. The ear is slightly tapering, the rows are closely spaced, distinctly dove-tailed, and average from sixteen to twenty-two in number. The kernels are slightly keystone in shape, of medium depth and narrow to medium in width, with a square crown and a smooth to rough indentation. The normal color is yellow, but the reddish tinge of the Gordon Hopkins often appears. The cobs are inclined to be small and are dark red in color. The stalk is rather heavy, tall and leafy. The

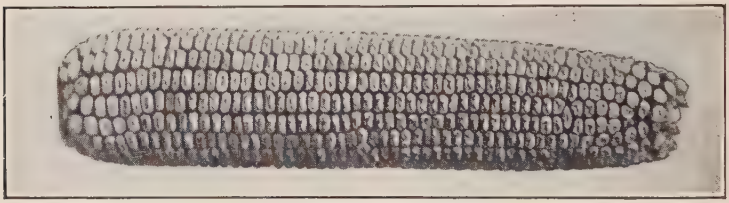


Fig. 70.—Reid corn (rough type).

ears are often borne a little too high on the stalk unless care is taken in selection. The general opinion seems to be that Reid Yellow Dent cannot be surpassed on rich soil where it has become acclimated.

Reid Yellow Dent requires from 110 to 120 days to mature and should be classed as medium late. At present, due to wide adaptability, it is the most common yellow variety in the Corn Belt, although the type necessarily has been modified to fit many different conditions. The type as now generally grown is rougher than the type which Reid originally preferred.

Outstanding strains of Reid corn are Iodent, Black, McCulloch and Krug. Iodent is an early Reid developed by L. C. Burnett, after years of painstaking ear-row work at the Iowa station. Black has resulted from a cross of Iodent and a late show type of Reid, made by Clyde Black, of Dallas County,

Iowa. McCulloch was produced by selection from a cross of a small amount of Pride of the North with a large amount of Reid. Fred McCulloch, of Iowa County, Iowa, was the originator. George Krug, of Woodford County, Illinois, in 1903, crossed Gold Mine with a Nebraska strain of Reid and has developed Krug corn by selecting continuously for a smoother, rather small-eared type. All of these strains have demonstrated their ability to yield. (See Chapter XVII, on Corn Yield Contests.)

Boone County White

Boone County White was originated in Boone County, Indiana, by James Riley. In 1876, he obtained his foundation stock, which was a large, coarse, late-maturing variety of corn known as White Mastodon. The stalk is heavy and rank, with short inter-nodes and abundant foliage. The ideal ear is $9\frac{1}{2}$ to $10\frac{3}{4}$ inches long and $7\frac{1}{2}$ inches in circumference. The shape is nearly cylindrical, with straight rows, sixteen to twenty-two in number and of medium spacing. The butts are rather large and open, with shallow cavity. The cob is white and is rather large and heavy. The kernels are thick and blocky, medium to wide, and medium to deep. The normal color is a creamy white and the usual indentation is rather rough.

Boone County White is a late-maturing variety of corn, requiring 120 to 125 days. It is grown chiefly in the southern Corn Belt, and on account of its late maturity is not well adapted to the remainder of the Corn Belt. However, it is a popular corn on the rich land of the sections where it is adapted. Boone County White and the related Johnson County White are far more widely grown than any other white Corn Belt varieties.

Leaming

Leaming corn has been developed since 1856, according to W. A. Lloyd, of the Ohio station. It did not originate in 1826. Mr. Lloyd says: " Manifestly, J. S. Leaming could not, as it is

often stated, have originated this corn at that time (1826)." J. S. Leaming, in developing Leaming corn, placed special emphasis on early maturity. He thought that a rather short stalk, heavy at the butt and tapering rapidly, bearing a tapering ear, was the type that matured earliest. The original Leaming corn ripened in from 90 to 100 days.

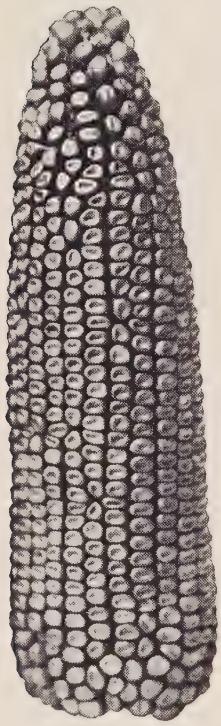


Fig. 71. — Leaming corn (original type, as favored by J. S. Leaming).

The present-day type of stalk is still medium in height. The ideal ear is 9 to $10\frac{1}{2}$ inches in length and 7 to $7\frac{3}{4}$ inches in circumference, with large, rather open butt and distinctly pointed tips. The rows vary from sixteen to twenty-four in number. The kernels of true Leaming are medium in depth, very thick and rather narrow. Leaming is a deeper yellow than most yellow dents. The indentation varies from smooth to rough, but in the original Leaming the smooth type was preferred.

It is grown most extensively in the central and eastern parts of the south-central Corn Belt and to some extent in adjoining sections of the north-central Corn Belt. Leaming became popular in the eighties and nineties, partly because of the publicity it received from winning prizes at the World's Fair in Paris in 1878.

Silvermine

Silvermine originated with J. A. Beagley, of Sibley, Illinois, who started with a sample of white corn which won a prize at the Ford County, Illinois, institute in 1890. The Iowa Seed

Company, of Des Moines, bought his entire crop in 1895, for $1000, and originated the name, Iowa Silvermine.

Silvermine is not a rank-growing variety, and even on rich soil it does not produce as heavy foliage as some varieties. The stem is of a fine texture and there is little coarseness about the joints. The ears are medium in size, being from 9 to 10 inches in length and from 7 to $7\frac{1}{2}$ inches in circumference. They are cylindrical for about two-thirds of the length of the ear and then slowly taper off at the tip. The kernels are of medium depth and width, but thin in comparison with their width. The dent varies from smooth to rough. The color is creamy white. The deep kernel and small cob of Silvermine give it a high shelling percentage.

Silvermine is adapted to a wide range of climate and soil and has the reputation of doing well on poor soils. It is a medium early corn, maturing in 110 to 115 days, and is well adapted to central Corn Belt conditions. It is the leading white variety just north of the section where Boone County White is widely grown.

Silver King

Silver King, also known as Wisconsin No. 7, was first developed as a variety by A. J. Goddard, of Fort Atkinson, Iowa, who brought a bushel of the seed from Indiana to Fayette County, in 1862. Mr. Goddard selected for early maturity and yield. To improve the yield, he selected fairly large ears with deep, wide kernels, a medium to small cob and closely spaced rows. One of the valuable characteristics of this corn is its freedom from barren stalks. The ideal ear is 8 to 9 inches long and $6\frac{3}{4}$ to $7\frac{1}{2}$ inches in circumference. There is a gradual taper from butt to tip, and the rows average sixteen to the ear and are inclined to be wavy. Silver King has creamy white kernels which are very wide, of medium depth and thickness, slightly keystone in shape. The usual indentation is rough. It is one of the earliest maturing of the prominent varieties, maturing in

100 to 110 days. It is the leading white variety in the section of the Corn Belt immediately to the north of the Reid Yellow Dent territory. Some Silver King is grown as far south as Missouri, but only for late planting or replanting.

Kansas Sunflower

Kansas Sunflower originated from an early yellow variety of corn introduced from Iowa into Douglas County, Kansas, in 1887. John Moody, of Eudora, Kansas, obtained seed of this variety in 1890, and continued growing it for some time, carefully selecting the seed each season. Five years later he sold his entire crop to the Barteldes Seed Company, of Lawrence, whence it was distributed under the name of Kansas Sunflower.

The stalks grow from 8 to 9 feet in height, are fairly leafy, and under favorable conditions sucker rather badly. The variety is a hardy and vigorous grower. The ideal ears are 9 to 10 inches in length and 7 inches or slightly less in circumference. The ears are rather slender and taper slightly, carrying ordinarily fourteen to eighteen rows of kernels. The kernels are broad, medium deep and of medium indentation. The grain of Kansas Sunflower is a bright, rich yellow.

Kansas Sunflower is a medium late variety, which ripens in 120 to 125 days. It is well adapted for growing throughout eastern Kansas. Because of the slender ears and lack of show characters, Kansas Sunflower has not been a very popular variety, even though it has consistently given good results.

St. Charles White

The St. Charles White is a native of St. Charles County, Missouri, where it has been grown for a great many years. Two types of this corn are recognized—the small St. Charles and the large St. Charles, the former being slightly earlier and better adapted to thin lands.

The ears taper somewhat from butt to tip. The cobs possess the striking peculiarity of being blood-red in color. The St. Charles White is a late-maturing variety, averaging 125 to 130 days for complete maturity. It is a rank-growing variety with adaptation similar to Boone County White. It is useful as a silage variety.

Commercial White

The Commercial White corn was originated by P. E. Crabtree, of Barton County, Missouri, who developed the corn by selecting the white-cobbed ears of the St. Charles White. The ideals which have been kept in mind in selection are uniform kernels of medium depth, with a low amount of crown starch and large germs.

The ears are larger in circumference and more cylindrical than are those of the St. Charles White, but often taper quite abruptly at the tip. The rows are straight and distinctly paired. The butts have a tendency to be flat and often have a large shank. The kernels are broader than those of St. Charles White and are only of medium depth. They are thick and a trifle more wedge shaped than the St. Charles White and more rounded at the top. They possess a small amount of crown starch and are pearly white in color. The indentation is medium smooth.

Commercial White is a late maturing variety which requires 125 to 130 days for complete ripening. It is a tall growing corn, averaging about 9 feet for the state, and very leafy. The stalks are very strong and stocky. The cob, which has a tendency to dry slowly, prevents as high a grade of market corn as either Boone County White or St. Charles White. It is a good silage variety. Missouri co-operative tests have shown it to be the highest yielding variety on the black prairie uplands of the state.

Minnesota 13

Minnesota 13 was originated by ear-row breeding at the Minnesota experiment station, from seed purchased in 1893, from a St. Paul seed company. Probably it was from Pride of the North. The ideal ears are 7 to 8 inches long and $6\frac{1}{2}$ inches in circumference. There are twelve to sixteen rows and the ears are slightly tapering. They have yellow kernels and a red cob. The kernels are shallow and have a dimpled dent. It is an early-maturing but heavy-yielding variety, adapted to the region extending from southern Minnesota northward.

Golden Glow

Golden Glow, which is the most popular yellow dent in Wisconsin, was originated by the Wisconsin station by crossing a Wisconsin strain of Minnesota 13 with a somewhat later and larger-eared variety long grown in Wisconsin under the name of North Star. After several years of selection, the new variety was distributed by the Wisconsin station.

Hogue Yellow Dent

Hogue Yellow Dent has been grown by R. Hogue, of Crete, Saline County, Nebraska, since 1885. He obtained the corn from Lancaster County, Nebraska. The history of the corn previous to that time is not known. Mr. Hogue has carefully selected the seed each year, having particularly in view a deep kernel. The result is an ear with rather deep kernels, deeply indented and fairly late maturing. One characteristic of the corn is a thick, medium tall stalk with long, broad leaves, giving a large amount of foliage. The variety has never been intentionally crossed since Mr. Hogue obtained it. Mr. Hogue has never undertaken to select for uniformity of kernel type or ear; in fact, he has always intentionally selected and mixed several ear types for his seed supply.

The standard for type adopted by the Nebraska Corn Improvers' Association is: Shape of ear, slightly tapering; length of ear, 8 to 9 inches; circumference of ear, 7 to 8 inches; color of kernel, yellow; shape of kernel, wedge; indentation of kernel, rough; number of rows, sixteen to twenty; size of shank, medium; size of cob, medium; color of cob, red.

The variety requires approximately 120 days to mature and is not well suited under conditions of a shorter growing season. It is extensively grown in eastern Nebraska and central Kansas.

Johnson County White

Johnson County White was originated by J. D. Whitesides in Johnson County, Indiana, in 1893, from a cross between Boone County White and Forsythe's Favorite, and was improved by several farmers.

The ideal ears are about $9\frac{1}{2}$ to $10\frac{1}{2}$ inches long and $7\frac{1}{2}$ inches in circumference. They are about the same size as Boone County White, but are slightly more tapering. The kernels are narrower and more nearly square at the crown than Boone County White. They are also deeper, rougher and more starchy in composition, which gives them a starchy white color.

Johnson County White matures in 120 to 125 days, and is adapted to the southern Corn Belt, but is too large and late maturing north of southern Iowa. It is replacing Boone County White in many localities.

Freed White Dent

This variety was developed by J. K. Freed, of Scott County, Kansas, who began by selecting a badly mixed variety of a local corn for the purpose of establishing a more uniform type of ear and kernel. The original source of the foundation stock is unknown. The corn has been grown in western Kansas for at least thirty years.

Freed White Dent ranges in height from 6 to 8 feet, depending on the growing conditions. The stalks are sturdy, fairly leafy, and are likely to sucker extensively under favorable conditions, but not to so great an extent as most other western developed varieties. The ideal ears are 7 to $8\frac{1}{2}$ inches long and $6\frac{1}{2}$ to $6\frac{3}{4}$ inches in circumference. The number of rows of kernels varies from twelve to sixteen. The kernels are rather shallow and medium in width and thickness. The dent is smooth and the kernel texture is flinty.

Freed White Dent is an early variety, which matures in 105 to 110 days. It is primarily adapted for growing in western Kansas and on the uplands in west-central Kansas. Because of its hardiness and vigorous growing habits, it is an exceptionally high-yielding early corn for growing anywhere in Kansas.

Northwestern Dent

The origin of Northwestern Dent is doubtful, but almost certainly was the result of crossing a dent and a flint, one of which was red. It is a semi-dent variety that normally produces more suckers and leaves than any other common dent. The ear is 6 to 9 inches long with ten to fourteen rows of kernels. The kernels are red with a white or yellowish crown. It is a hardy corn adapted to the extreme northern part of the Corn Belt, and is the best-known variety in the northwest.

Wimple Yellow Dent

Wimple Yellow Dent was developed by Mr. Wimple, of Beresford, South Dakota. The ideal ears are 8 to $9\frac{1}{2}$ inches in length and tapering in shape. The kernels are wide with a short beak dent and are lemon yellow in color. It has a larger ear and considerably heavier stalk than Silver King. Wimple Yellow Dent matures in from 105 to 115 days. It has been grown in the northern part of the Corn Belt for a number of

years. The originator has recently developed a smoother, earlier strain.

Funk Yellow Dent

Mr. Funk, of McLean County, Illinois, secured the original seed from James Reid, about thirty years ago. Since that time, popular opinion has demanded several variations in type. For a time, it was bred for a rough type, but in recent years the emphasis has been on the smooth.

A popular utility type of corn is Funk Yellow Dent, Strain 176-A. . The ideal ears are 9 to 11 inches long and 7 to 8 inches in circumference. This variety conforms just as nearly as possible to the utility type score card. The story of how this strain of corn has been developed from Funk Yellow Dent is as follows:

" In germinating several hundred bushels of seed corn during the winter of 1915 and 1916, we occasionally noted a few ears on the germinator that were remarkably free from molds and rotting and that possessed unusual vigor and magnificent root development. These ears proved their superiority in the field during the following season, by far outclassing everything else in the experimental plots. The progeny from these champion mother ears have been multiplied and improved further by special breeding methods."

Calico

Strains of Calico have been developed by different growers. The shape of the kernel, dent, character of stalk and length of growing season vary considerably, depending upon the grower. The ears are from 9 to 11 inches long and almost cylindrical. The kernels are variegated in color, ranging from pink to red, depending upon the amount of red in the striping, but there are sometimes groups of kernels of solid white, red or yellow. It is quite widely distributed and has no fixed characteristics. Many strains are early to medium maturing. These are well adapted to western Corn Belt conditions.

Bloody Butcher

Bloody Butcher is a name applied to strains having a deep red grain. The crown of the kernel varies in color for the different varieties, but is usually lighter than the remainder of the kernel. As a rule, Bloody Butcher corn is not any more productive than corn of any other color. Like Calico, the different varieties of Bloody Butcher vary greatly, as do those of the white and yellow varieties. The red color is in the hull only; beneath the hull, some Bloody Butchers are white and some are yellow.

Other Varieties

Several of the important varieties in addition to the ones just described are:

Early White Dent.—Marten White Dent (Great Plains); Payne White Dent (Great Plains); Pioneer White Dent (Northwest); Rustler White Dent (Northwest), and Webber Early Dent (Great Plains).

Medium to Late White Dent.—Brazos White (Texas); Champion White Pearl (Illinois); Chisholm (Southwest); Cob Pipe or Collier (Missouri); Democrat (Illinois); Easterly White (Illinois); Eureka (general); Farmer's Pride (eastern Corn Belt); Farmer's Interest (eastern Corn Belt); Faulkner (Illinois); Forsythe (Kansas); Hammett (Kansas); Iowa Ideal (Iowa); McAuley (Kansas); Mexican June (Southwest); Munikhysyen (Southeast); Nebraska White Prize (Nebraska); Pride of Saline (Kansas); Roseland (Kansas); Shawnee White (Kansas); Sherrod White Dent (Kansas); Surcropper (Southwest); Tuxpan (Southwest); Vogler White Dent (Indiana) and White Wonder (Oklahoma).

Early Yellow Dent.—Ardmore Yellow (South Dakota); Brown County Yellow (Northwest); Golden Surprise (Ohio and Illinois); Kossuth County Reliance (Iowa); Minnesota King

(Minnesota); Murdock (Wisconsin); Pride of the North (general); Robertson Yellow Dent (Northwest), Golden King (Iowa), and Falconer (Northwest).

Medium to Late Yellow.—Bear Paw (Ohio); Cartner (Missouri); Champion (Ohio); Clarage (Ohio); Cuppy (Ohio); Darke County Mammoth (Ohio); Early Yellow (Indiana); Ferguson (Southwest); Giant Beauty (Southeast); Golden Beauty (Missouri); Golden Eagle (Illinois); Golden Gem (Southeast); Golden King (Illinois); Goldmine (general); Hiawatha (Kansas); Hildreth (Kansas); K. B. Yellow Dent (Iowa); Lancaster Sure Crop (Pennsylvania); Legal Tender (general); Midland Yellow (Kansas); Monitor (Ohio); Riley Favorite (Indiana); St. Charles Yellow (Missouri); Shroll Yellow Dent (Ohio); Skipper (Southeast); Wabash Yellow (Indiana); Western Plowman (Illinois), and Yellow Jumbo (Ohio).

Miscellaneous Dent.—Blue and White (scattered); Devolid (Ohio); Early Red (scattered); Hackberry (Ohio); Hecker Red (Illinois); Lenocher Homestead (Iowa); Minnesota 23 (Northwest); Old Glory (Texas); Rotten Clarage (Ohio); Strawberry (general); Stony Hill White Cap (New York); Strout Red (Illinois); Swadley (Great Plains), and White Cap Y. D. (general).

Cotton Belt single ear.—Lowman (yellow); Shenandoah White (white); Southern Beauty (white); Wyatt Improved (yellow); Hickory King (white).

Cotton Belt prolific.—Bigg Seven Ear (white); Cocke Prolific (white); Garric (white); Hasting Prolific (white); Hickory King (white); Jarvis Golden Prolific (yellow); Marlboro Prolific (white); Mosby (white), and Sanders (white).

New England flints.—Hall Gold Nugget; King Philip; Longfellow; Mercer; Rhode Island; Sanford White; Smut Nose.

Northwestern flints.—Assiniboine; Burleigh County Mixed; Cassia County; Dakota White; Fort Peck Indian; Gehu; Howe's Alberta.

Southern flints.—Creole.

Argentine yellow flints.—Canario; Colorado, and Piamontese.

Australian dents.—Fitzroy and Red Hogan.

Italian yellow flints.—Cinquantino; Nostrano Isola; Pignoletta d'oro; Rostrato, and Scagliolo.

Soft corn.—Ivory King; Mixed; Rea, and Brazilian Flour.

South African.—Potchefstroom Pearl; Natal Eight-row; Hickory King.

CHAPTER XVI

CORN BREEDING

Special corn-breeding methods do not pay on the average farm. Most farmers who have a good, acclimated variety are justified in doing nothing more than picking well-matured, solid ears, free from mold, every fall before frost. In addition, it may be well to see that the ears come from stiff stalks and are borne at a convenient height from the ground. Suggestions along this line are given in Chapter I.

Every few years, however, it is a good plan on one side of the field to grow side by side with the home variety of corn another sort which has a well-founded reputation for high-yielding power. If this supposedly high-yielding corn from the outside does unusually well, it may be a good plan to start all over with it or to mix it with the home corn. No special methods are necessary in this kind of corn breeding. Practical farmers have followed this general plan for fifty years, and only recently has it become apparent that a better method may possibly exist.

Four general methods of corn breeding have been practiced by corn breeders: (1) selection, (2) ear-row breeding, (3) cross-breeding and (4) inbreeding followed by crossing.

Selection

Nearly all commercial varieties of corn have been formed by selection preceded oftentimes by a certain amount of cross-breeding. The famous Illinois experiments started by Cyril G. Hopkins in 1896 and maintained for many years by Louis H. Smith have demonstrated that unusual changes in type may be

obtained by long-continued selection. After eight or ten years of selection for low ears at the Illinois station, they obtained a strain which on the average carried its ears less than 2 feet from the ground, whereas another strain developed from the same original Leaming, but selected for high ears, carried its ears more than 7 feet from the ground. After twenty years, a strain of corn selected for high oil contained over 10 per cent on the average, as contrasted with 2 per cent for the strain selected for low oil. In like manner, a high protein strain containing 16 per cent protein was developed and a low protein strain containing 6 or 7 per cent. In every case but one, however, these

FIG. 72.—Low ear and high ear corn at Illinois Station, developed by selection from same original Leaming.

selections resulted in reduced yielding power. The one exception was the strain selected for two ears, which at last reports from the Illinois station, was still yielding about as well as Reid corn. The other selections have yielded on the average only about three-fourths as well as Reid corn. It seems that selection for one particular thing results after a time in close breeding and that this reduces the vigor.

Most of our early corn breeders assumed that a moderately large ear with a deep kernel and a well-filled butt and tip was fundamental to yielding power. They selected for this one

thing above everything else in developing our modern types of corn. In all probability, the pioneer corn breeders, by following this method, brought about a slight increase in the yielding power of the corn which they had received from the Indians. It has been found, however, by repeated experiments during the past twenty years that in our modern Corn Belt varieties, no ear character is so very closely associated with yield. At the Ohio station, the growers selected for shallow-grained corn year after year for a number of years, but the yield of shelled corn per acre was not impaired thereby. Seed from ears with bare tips seems to yield just as well as seed from ears with well-filled tips. By selection, it is possible to develop corn of beautiful appearance, but it seems to be very difficult to develop corn of outstanding yielding power. So far as we know now, very few of the stalk or ear characteristics which we can see with the eye are at all closely related to yield in our ordinary varieties of Corn Belt corn. It is obvious, of course, that, in the case of a corn which is too late for the season, one of the things which must be done is to pick for a smaller ear and stalk, and vice versa. But in the case of a well-acclimated strain no method of selection has yet been found which has so very much effect on yielding power. It has been found possible to alter the appearance of the ear and stalk considerably, but the improvement of the yielding power by any method of selection has been found to be very difficult.

Breeding Methods

Ear-row breeding.—In the closing years of the nineteenth century and the opening years of the twentieth, the Illinois and Ohio stations developed the "ear-row" method of corn breeding. The theory of this method seemed so sound that every one had great hope that the inherent yielding power of corn subjected to this method of breeding would be greatly increased.

To begin with, fifty or a hundred good ears of a high-yielding

strain were picked out. These were planted an ear to a row, part of the seed from each ear being saved for planting the year following. Each row was weighed up separately in the fall, and it was invariably found that some of the good rows would yield about twice as much as the poor rows, and ten or twenty bushels per acre more than the average of the field. The plan was then to go back to the remnant seed of the fifteen or twenty ears which had produced these high-yielding rows and plant them the following year in a small plot by themselves, an ear to the row. It was supposed that seed saved from this plot would yield much more than the original corn. As a matter of fact, the results were not so very encouraging. This was ascribed to inbreeding, and the method was modified to provide for detasseling of alternate rows and saving seed only from the detasseled plants. Much time and thought was spent on developing fine points in the method. In recent years, very little has been said about the ear-row method because no outstandingly high-yielding strain of corn has been developed by it. Here and there, practical farmers have used the method for a short time, but they have almost always dropped it after a year or two. At the Nebraska station it was found, after fourteen years of continuous ear-row breeding with Hogue Yellow Dent, that the yielding power has been decreased about one-third of a bushel per acre from the regular Hogue handled in the ordinary way. By crossing four of the high-yielding strains isolated by the ear-row method, the yield was increased about $1\frac{1}{2}$ bushels per acre, as an average of seven years' tests. It would seem that scarcely one farmer in a thousand is justified in making any effort to improve his corn by the use of the ear-row method. Even in the hands of expert corn breeders the ear-row method of increasing corn yields has not proved so very satisfactory.

Cross-breeding.—About 1910, a number of the experimental corn breeders became temporarily enthusiastic over the possibilities of improving yielding power by crossing two varieties. By planting two varieties in alternating rows and detasseling

the one, it is easily possible to obtain cross-bred seed to plant the year following. At the Connecticut and Minnesota stations, crosses between a high-yielding flint variety and a high-yielding dent have often been found to yield more than either parent. At the Michigan experiment station, in the late seventies, and at the Illinois experiment station, in 1892, cross-bred seed yielded several bushels more per acre than the higher yielding of the two parents. More recent and complete experiments, however, at the Iowa and Nebraska stations, indicate that very few crosses will yield as well as Reid Yellow Dent in Iowa or Hogue in Nebraska. As a four-year average, the highest yielding cross-bred corn at the Nebraska station was a cross of Reid and Hogue which yielded 45 bushels per acre as compared with 45.2 bushels for pure Hogue and 44.9 bushels for Reid. In one year the cross outyielded the Reid by 9 bushels and the Hogue by 4 bushels, but in the other three years the pure parents had the advantage. Thirteen different crosses at the Nebraska station yielded as a four-year average 1.6 bushels per acre less than the average of their parents. At the Iowa station, the results have been much the same, no cross of varieties consistently outyielding Reid Yellow Dent. The bulk of the evidence indicates that crossing two dent varieties is not ordinarily worth while, but that the crossing of flints and dents may have some possibilities. It seems that the average Corn Belt farmer will not find it worth while to produce cross-bred seed himself, and, unless some new and startling combinations are found, it is very doubtful if it will pay him to buy cross-bred seed from anyone else.

Inbreeding

The newest method of corn breeding is based on developing inbred strains of corn by putting the pollen of a plant on the silk of the same plant and continuing this "selfing" generation after generation until after four or more generations absolutely distinct inbred types have been produced. The inbreds as

usually developed by this method yield about 20 bushels per acre under the same conditions that ordinary corn yields 50 bushels. When two unrelated inbreds are crossed, however,

FIG. 73.—On the left an inbred, which was developed after five years of selfing. On the right inbred No. 1–6 of the Connecticut Station, which has been selfed for seventeen years. In the center the cross of the two, which is a vigorous, productive type, producing more than Reid corn and twice as much as either inbred parent.

startling results usually follow. At the Nebraska station, where all other methods of corn breeding have failed to produce a higher yield than Hogue Yellow Dent, as grown in the ordinary

way, it was found, as a four-year average, that the cross of eight sets of two inbreds each yielded 48 bushels, as compared to 41 bushels for the Hogue in the same years. Occasionally two inbreds do not " nick " well, and yield only half as much per acre as the variety from which they were derived. On examination, it will generally be found that inbreds producing such results are either closely related, or have some serious weakness in common, or are weaker than the average inbred. At the Connecticut station, where corn has been inbred for a greater number of generations than anywhere else in the world, it has been found that, while crosses of two inbreds have often yielded more than the original variety, even higher yields were obtained by crossing four inbreds together to produce a " double cross." This takes two years. For instance, if A, B, C and D are the inbreds, the method is to produce single crosses, AB and CD, the first year and then cross these the following year to produce double cross ABCD. This double-crossed ABCD seed, when planted, has given exceptionally good results at the Connecticut station. The single-crossed seeds produce plants and ears which are very uniform, every plant and ear looking almost exactly like every other plant and ear. The double-crossed seeds, however, produce plants and ears which vary from one another about as much as is the case in the ordinary variety. This variability may account in some measure for the double-crossed seed yielding more than the single-crossed.

Practical method for farmers.—What the final practical outcome will be of this new theory of producing inbred strains and then combining them into single, double or even quadruple crosses, no one can say. The method looks promising, but there are some drawbacks. The cross must be made every year. Seed selected from a high-yielding single cross is very disappointing in its ability to yield the next generation. It promptly lapses back toward its inbred form, and usually yields only about three-fourths as well as the year before. If this crossing of inbred strains is ever used in a practical way it probably will be necessary for Corn Belt farmers to buy their seed

every year from seedsmen or seed associations which are specializing on this kind of thing. However, it may be that further experimenting will demonstrate that it will be possible after forty or fifty good inbreds have been located which are mutually compatible to combine them together in the form of a new variety, with the result that the yielding power of this complex cross will not slide downhill in later years in the same way as a single

FIG. 74.—Inbred *A* on right was crossed with inbred *B* on left. The *AB* crossed seed when planted gave the strong, vigorous stalks in center which are much more productive than either inbred parent.

cross or a double cross. Just what the application of breeding and cross-breeding inbred strains will be, no one can say with any certainty. It does seem to be plain, however, that this method offers the best hope of making any genuine progress in corn breeding. Nevertheless, it is probable that not until after 1930 will this new idea in corn breeding have gone far enough to mean anything one way or another to the practical corn

farmer. For the time being, the practical thing for him to do is to save sound seed of a standard high-yielding strain in the manner suggested in Chapter I. From time to time, the more experimentally minded can try out corn which has done well in corn-yield contests and also single and double crosses of inbreds which may be offered by experiment stations and seed companies as time goes on.

It is interesting to note in the Iowa corn-yield contest, in 1924, 1925, 1926, and 1927 that crosses of inbreds have consistently outyielded the open pollinated sorts. The lead of the best hybrids has been 5 to 10 bushels per acre over the regular Reid strains. If further experiments continue to prove that crossed inbreds have such an advantage it will pay to go to considerable pains to produce such seed. A bushel of corn will plant seven acres and if the increased yield per acre is only 4 bushels it will be seen that with corn at 70 cents a bushel, seed of the right kind of crossed inbreds may be worth $20 a bushel more than ordinary seed corn.

Nearly every experiment station in the Corn Belt is producing inbred strains of corn and trying to determine just which ones combine to produce the highest yield. The best inbreds for crossing purposes will be ready for distribution by some of the stations by 1930. The problem then will be to get these inbreds into the hands of reliable, well-trained people experienced in producing seed corn, who can be relied upon to do a good job of crossing the inbreds so that farmers who buy will know just what they are getting. State certification may be necessary.

Technique of Inbreeding

Inbreeding involves placing live pollen of a plant on the silks of the same plant and also keeping out any foreign pollen. The customary way of doing this is to tie a 12-pound pinch bottom paper sack over the tassel just before it begins to shed pollen. A 3-pound paper sack or a glacine bag ($2\frac{1}{2}$ by 5 inches is

a convenient size) is slipped over the ear shoot as soon as it is out far enough so as to hold the bag on, and before any silks have appeared. Thump the tassel bag to tell when the pollen has started to shed. If the silks are out and pollen is shedding, take the tassel sack off and invert it over the ear shoot and tie it, allowing the bag to bend in the middle while tying so as to avoid losing the pollen. After the tying is completed, straighten out the bag and shake it suddenly, so that a considerable amount of the pollen in the bag will fall on the silks enclosed in the bag. Paper clips may be used instead of string to hold the sacks in place over the young ear shoots. The sack is folded once or twice behind the ear shoot and one paper clip suffices to hold the sack in place.

FIG. 75.—Illustrating hand pollination of corn when bottles are not used.

New method.—In 1922, a new technique of inbreeding was devised by Merle T. Jenkins, of the United States Department of Agriculture. It is known as the bottle method, and has several advantages for people who are inbreeding more than 100 plants a year. With the bottle method, the ear shoots are covered up in just the same way as with the old-fashioned method, but the tassels are not covered at all. When the silks are out and the tassel has begun to shed, the tassel is pulled out

and put in a 12-pound pinch-bottom paper sack and the base of the tassel is placed in a 1- or 2-ounce bottle filled with water and tied to the corn stalk at the same place as the ear shoot comes out. The paper sack encloses both the ear shoot and tassel and is held in place by a paper clip or a string. The silks of the shoot

FIG. 76.—Paper sack keeps foreign pollen from getting on silks.

are cut back together with the tips of the husks for an inch, or even 2 inches, just before the 12-pound sack with its enclosed tassel is put over it. A day or two later the silks grow out again and the water in the little bottle has kept the tassel alive so that it is still ready to furnish pollen when the silks are ready again. The bottle is most quickly attached to the

stalk by means of rather heavy copper wire of about No. 16 gage, one end of which is twisted around the neck of the bottle. The wire is pulled down between the ear shoot and the stalk, and it will be found that the pressure of the base of the ear shoot against the stalk will be sufficient to hold the wire with the

FIG. 77.—Cutting off the silk and putting bottle in place.

bottle attached to it. The bottles are carried to the field in a water bucket. The bottle method appears to be more difficult and complicated than the old-fashioned way, but in actual practice is much more rapid. Two men can inbreed forty to sixty plants an hour. One very great additional advantage is that rain often drove water into the tassel bags used in the old-

fashioned method, making it necessary to do a lot of work in replacing them, and sometimes making it impossible to inbreed certain plants at all.

Growth of tassels and silks.—Following are some facts about the flowering habits of our typical Corn Belt stalk of

FIG. 78.—Tassel is put in bottle and both the tassel and the ear shoot with silks cut back are covered with paper sack.

corn, which may be worth while to anyone who is expecting to do some inbreeding:

1. From the time the tassel first appears until the first pollen is shed is usually about a week.
2. Silks usually appear two or three days after pollen shedding first

begins, although there are occasional plants whose silks come out a day or two in advance of the pollen.

3. Pollen shedding continues for about a week, although a few plants produce tassels which will continue to shed for ten or twelve days.

4. With a moist atmosphere and a rather low temperature, corn pollen may live two or three days, but with temperature and humidity as it usually is in the ordinary corn field, nearly all of the pollen dies within twenty-four hours after it leaves the tassel.

5. Silks are receptive to pollen for two weeks or even longer after they first appear. If they are not fertilized, they may grow to a length of 10 or 12 inches, although in the case of some plants the unfertilized silks make very little more growth than the fertilized. After a pollen grain falls on a silk, it grows with great rapidity, germinating and sending a pollen tube through 7 or 8 inches of silk to the ovule (unfertilized corn kernel) within twenty-four hours.

6. If a tassel is pulled before it begins to shed pollen, it will rarely live to shed, even though it is placed in water. However, after a tassel has begun to shed it may be pulled and continue to produce viable pollen for a day, even though it is not placed in water.

7. There is considerable difference in the habits of different corn plants, but the typical plant acts about as described in the foregoing.

Heredity in Corn

In corn, as in other plants and in animals, the hereditary characteristics are carried over from one generation to the next in the male and female germ cells. The male germ cells are the pollen grains and the female germ cells are the unfertilized ovules or kernels found at the base of the silks. Each male germ cell or pollen grain contains ten chromosomes and so does each female germ cell. The chromosomes are the parts of the germ cells which carry the hereditary material. One chromosome, for instance, may carry the factor which makes the kernels sweet, whereas, another in the same pollen grain may carry a factor which makes the kernels yellow in color.

To make a fertilized corn kernel, a pollen grain with its ten chromosomes must fall on the silk of a corn plant and then grow down the silk into the ovule, where the ten chromosomes of the pollen grain unite with the ten chromosomes of the ovule. The corn embryo, therefore, and the plant which grows from it,

contains twenty chromosomes. Only the germ cells contain ten. About three or four weeks before corn comes into tassel, what might be called the pre-germ cell material still contains twenty chromosomes. At this time the pre-germ cell material gets ready to form real germ cells with ten instead of twenty chromosomes. This process is known as the reduction division.

Xenia.—When yellow corn pollen fertilizes a white corn ovule, the kernel which develops is light yellow in color. When the reverse takes place, and white corn pollen fertilizes a yellow corn ovule, the kernel which develops is almost as yellow in color as though the fertilizing had been done by yellow corn pollen. When white or yellow corn ovules, however, are fertilized by red corn pollen, the resulting kernels are white or yellow, just as though white or yellow pollen had been used.

The immediate effect which corn pollen has on the corn kernel which develops immediately after fertilization is known as xenia. The corn germ cells contain nuclei other than those which form the embryo. The male germ cells or pollen grains have one of these additional nuclei and the female germ cells have two. In fertilization, this one additional nucleus of the pollen grain joins with the two extra nuclei of the ovule, and this combination governs in large measure the development of that part of the corn kernel which is outside of the germ and under the hull. Because it is formed by three nuclei this material contains thirty chromosomes. The hull is a part of the mother plant, and it is impossible for the pollen grain to affect its color. Red color in corn is usually found in the hull, and that is the reason red pollen has no immediate effect on the color of white or yellow corn. Red corn can grow alongside white corn and no results will be seen that year, but the year following, if the white corn is saved for seed, there will be some plants producing red ears.

The fact that the ovule has two extra nuclei and the pollen grain only one explains why white corn pollen has a slightly different effect on a yellow ovule than yellow corn pollen has on a white ovule. The yellow color is found in the horny starch

of the kernel and is therefore governed right away in its development by the combination of the one extra nucleus of the pollen grain with the two extra nuclei of the ovule. When there are two doses of white to one of yellow, it is to be expected that the color should be a little paler than when there are two doses of yellow to one of white.

Sweetness of the corn kernel, being in the endosperm, is governed by xenia, although no one has proved that it makes any difference which way the fertilization takes place. If sweet ovules are fertilized by ordinary pollen, the kernels seem to be just as starchy as though the ordinary corn ovules were fertilized with sweet pollen.

Just under the hull, as will be noted on page 183, of Chapter XIII is the aleurone layer, which is susceptible to xenia. The most common xenia effect in the aleurone is a blue color, the heredity of which is very complex. Generally speaking, when blue corn pollen fertilizes white or yellow corn ovules, the result is kernels blue in color.

Briefly, it may be said that the common xenia effects in corn are with the following pairs of characters, the dominant being named first:

Blue color versus no color in the aleurone.
Yellow color versus no color in the horny starch.
Starchy corn kernel versus sweet corn kernel.

Red color is never a xenia effect except in the case of a very rare and dull kind of red, which acts in the same way as blue, manifesting its color through the aleurone.

Mendelian characters.—Most of the corn heredity work has centered around the problem of finding which characters are Mendelian dominants and which Mendelian recessives. More than one hundred Mendelian characters have already been discovered, and by 1935 several hundred more will undoubtedly be worked out. Many of these characters are freaks which so affect the plant that it does not have the capacity of producing an ear which a farmer would save for seed. In spite of this,

they are found to some extent in nearly all corn-fields. They seem especially likely to be found in rather large numbers on those farms where a special effort has been made to breed a high-yielding strain of corn by the ear-row method. One of the commonest of freaks is a white stripe running through the leaves. A plant of this sort when inbred and the seed planted produces plants all of which are affected with striped leaves. But if the silks of a striped-leaved plant are fertilized with pollen from a normal plant, and the seeds produced are planted, the result will usually be plants all of which are normal. Occasionally, a plant which appears normal carries the striped character in one-half of its pollen grains, and when the pollen of such a normal plant is used on the silks of the striped plant the result will be plants one-half of which carry striped leaves and one-half of which are normal. Normal plants which are produced in this way bear pollen one-half of which carries the striped-leaf factor and one-half of which are normal. Also, one-half the ovules or unfertilized corn kernels carry the striped leaf factor and will produce a striped leaf plant if striped-leaf pollen falls on their silks. The striped-leaf character is known as a Mendelian recessive and normal leaf color is the Mendelian dominant.

Following are some of the Mendelian recessives, affecting the plant or leaf:

1. Blotched or mottled leaf.
2. Pale green leaf color.
3. Yellow leaf color.
4. Pure white seedlings.
5. Crinkly leaf.
6. Short jointed or the brachytic type of dwarf corn.
7. Crooked jointed or zig-zag corn.
8. Tassels with no pollen.
9. Leaves with a mid-rib but no real leaf.

Nearly all abnormalities, and there are hundreds of them, are Mendelian recessives. Some of the outstanding exceptions in the way of unusual characters which are Mendelian dominants are:

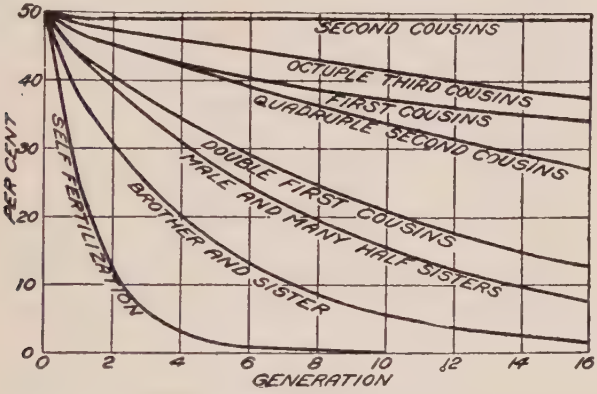
1. Purple plant color (governed by three dominant factors, A, B, Pl).
2. Brown plant color (determined by dominant B and dominant Pl with recessive a).
3. Pod corn or primitive corn with a husk covering each kernel.
4. Red kernels which owe their color to the red pericarp or hull.

Heterozygosity and how inbreeding affects it.—A plant or animal is said to be homozygous when all of its germ cells carry the same hereditary properties. Most corn plants are not homozygous, but are heterozygous (germ cells differ from one another). However, there are varying degrees of heterozygosity. For illustration, we may say that a completely homozygous corn plant produces germ cells each of which carries the inheritance ABCDEFGHIJ. A slightly heterozygous corn plant might carry half its germ cells with aBCDEFGHIJ and the other half with ABCDEFGHIJ. Actually, the ordinary corn plant carries dozens of different types of germ cells, as may be roughly illustrated in part as follows: ABCDEfghij; ABcdeFGhij; ABcdEfgHiJ; ABCdefghij; ABcDeFgHiJ, etc., etc. Perhaps this particular plant may be homozygous for A and B and heterozygous for all else. In the ordinary cornfield, it may be roughly assumed that the average plant is homozygous for about half of its characters and heterozygous for half. As long as wind pollination continues, and the farmer does not line-breed by planting closely related ears, there will be little or no change in the proportion of homozygosity and heterozygosity. If, however, a plant which is 50 per cent heterozygous

Courtesy of Connecticut Experiment Station.

FIG. 79.—Illustrating defective kernels. A Mendelian recessive.

is selfed, the next generation will bear germ cells which are much alike, and the probabilities favor only 25 per cent heterozygosity. In succeeding generations, the heterozygosity should decline to the following percentages: Second, 12.5 per cent; third, 6.25 per cent; fourth, 3.12 per cent; fifth, 1.56 per cent, etc. After five generations of selfing, it is a general rule that almost complete homozygosity is reached, provided the plant to start with was 50 per cent homozygous. It takes about



Bulletin 1121, United States Department of Agriculture.

FIG. 80.—Illustrating how a blood strain which is 50 per cent heterozygous is affected by different numbers of generations of different methods of breeding. Six generations of selfing should bring 99.2 per cent homozygosity if the strain was 50 per cent homozygous to start with.

seventeen generations of brother and sister mating to give the same degree of homozygosity as five generations of selfing.

Theory of hybrid vigor.—It is theoretically possible some day to find an inbred strain which is homozygous only for good qualities and which would therefore be vigorous. Actually, all inbred strains so far developed by selfing for four or more years are decidedly unproductive. When two different homozygous inbreds are crossed, the result is usually great vigor. This kind of vigor is supposed to be due to the fact that most

good characters are Mendelian dominants and most bad ones are Mendelian recessives, and that the first generation cross of two strains gives a chance for all of the good characters of both parents to appear, with none of the bad, unless the bad are found in both parents. It is this theoretically sound background which has caused so many experimenters to spend much time with corn inbreeding work in recent years.

Mutations.—Men who have inbred corn for six or more generations find that a great many strains are not 99 or more per cent homozygous. In many cases there is far more variability than would theoretically be expected. Sometimes after a strain has been reduced to uniformity, it will suddenly begin producing freaks of one sort or another. In some plants, as in the jimson weed, for example, it has been discovered by careful study that occasionally plants will be produced with twice the normal number of chromosomes. This doubling up of the chromosomes has not yet been observed in corn, but unquestionably the germ cells of a strain of corn which has been purified by inbreeding will occasionally mutate, which means that one or more chromosomes of a few of the cells will begin to act in a slightly different way. Some inbred strains of corn never seem to mutate, whereas others are quite susceptible. Inasmuch as mutation in corn cannot be studied at all satisfactorily until a strain has been inbred for at least six years, and preferably ten years, very little work has been done on this problem as yet. Some corn geneticists think that mutations in inbred strains of corn will make the method of crossing inbred strains impractical. The authors of this book, however, think that mutations in inbred strains will not prove to be a serious barrier to the eventual practical application of the method of crossing inbred strains.

What corn heredity means to the practical farmer.—In the present state of our knowledge, corn heredity does not mean so very much to the practical farmer, although by 1935 it may mean a lot. It is worth while for corn farmers to realize that every corn kernel is as definitely the result of a male and female

mating as is a cow. In the case of good livestock the farmer knows both the sire and dam. In the case of corn, however, he selects seed on the appearance of the dam only. That is the reason beautiful show ears do not reproduce themselves. Half the kernels on the show ear may have scrub sires. The breeder who controls only the dam half of the mating is certain to make very slow progress. At the present time, however, the practical farmer is not warranted in taking any pains to control the pollen with which his seed corn kernels are to be fertilized. Methods of corn breeding are described earlier in this chapter.

Sometimes breeders of yellow corn are troubled with their corn showing some very pale yellow or even white kernels. Is it difficult to get rid of the contamination? White color is recessive to yellow, and contamination will remain a long while, although it can gradually be reduced if only deep yellow ears are planted for a number of years.

When white corn is contaminated with yellow corn, the problem is simpler. Theoretically, if only pure white kernels are planted, the yellow contamination can be completely gotten rid of in one year. Actually, a few light yellow kernels are usually allowed to slip through. The problem of freeing white corn from yellow contamination is really quite simple, however.

Sweet corn contaminated with field corn is the same kind of a proposition as white corn mixed with yellow corn. If only sweet corn kernels are planted, the only chance for field corn contamination is from pollen which blows in that season. All the plants should be pure sweet corn plants.

When field corn is contaminated with sweet corn, it is an almost impossible job to get it completely out, although if only field corn kernels are planted, there will probably be, after three or four years, not more than one contaminated ear to ten acres.

If red corn is grown alongside white or yellow corn, there will be a number of kernels along the edge of the field fertilized with red pollen, although they will not show it because there is no xenia effect with red pollen. The next year every white or yellow kernel fertilized by red pollen will produce a plant bear-

ing a red ear, and these plants will scatter their pollen over the field. Half of these pollen grains borne by such plants will carry the red color factor, but it will be impossible to know which ears have had a few of their kernels contaminated. All that can be done practically is to plant only ears which are not red. But no matter how long this is kept up, there will almost certainly be a few red ears produced year after year.

Farmers who are interested in yield rather than appearance of their corn do not care a particle about a slight contamination of their corn with other colors or with sweet corn. But they are interested if their corn blows down badly or if it produces large numbers of white seedlings or other abnormalities which yield poorly. Sometimes farmers who are taking special pains with their corn-breeding work find that the abnormalities are increasing. If the situation gets serious, and there is more than one abnormal plant in every hundred, it may be wise to get an entirely new start of seed. Ordinarily, however, all that is needed is to plant seed only from strong, normal plants. By doing this, it is never possible to get completely rid of abnormalities, but it should be possible to keep them from getting really serious. So far as is known at this writing, the only way of producing a field practically free from abnormal plants is by the method of crossing proved inbred strains. Practical farmers may find it worth while to use crossed inbred seed for general planting after 1930.

The best bulletin on corn breeding is Department Bulletin No. 1489 of the United States Department of Agriculture.

Linkage.—The most recent step forward in corn heredity has been in the study of linkage, discovering which Mendelian factors are located in the same chromosome. Corn has ten chromosomes and it is probable that by 1935 nearly 100 different factors will have been placed. Not only this, but it will be possible to say about where in each chromosome each of the factors is located. This kind of work belongs to the professional geneticist at the present time. Eventually, it will have very practical applications because after the freakish factors are

definitely located in their various chromosomes it may be possible to locate the position of some of the factors which make for yield. In the meantime, it is worth while to know that this kind of work is going on and to be prepared to learn more about it when it finally begins to have some practical applications.

Alphabetical List of Genetic Factors in Corn

List furnished by Dr. Emerson, of Cornell University. Factors capitalized, dominant; not capitalized, recessive.

A—anthocyanin. General plant color including aleurone, pericarp, stem, leaves, etc.
ad—adherent. Leaves and tassel adhering.
an—anther ear. Semi-dwarf plant with anthers throughout ear.
ar—argentia. Silvery leaf.
B—"brown." A plant color factor. An allelomorphic series B, B^w, b.
bc—brachytic. Dwarf plant.
bh—blotched aleurone.
bl—blotched leaf.
[a]br—brown aleurone.
bv—brevis. Dwarf plant.
C—colored aleurone. Complementary to A and R.
co—coherent. Branches of tassel cohering.
cr—crinkly leaf.
d—dwarf plant with anthers throughout ear.
de—defective. Little or no development of endosperm and embryo.
[a]dt—dotted leaf.
f—fine striped leaf.
fi—fine streaked leaf.
fl—floury-flinty endosperm.
[a]Fs—fasciated ear.
g—golden leaf.
gl—glossy leaf.
gm—germless seeds.
gs—green striped leaf.
I—inhibitor of aleurone color.
in—intensifier of red and purple aleurone.
[a]Ir—interrupted ear.
j—japonica striped leaf.
l—luteus (yellow) seedling.

a Mode of inheritance not definitely established.

lg—ligueless leaf.
li—lineate leaf.
M—mottled aleurone—with heterozygous R.
mr—midrib. Leaf consists of but little more than the midrib.
ms—male sterile. Anthers produce no pollen.
na—nana. Dwarf plant.
nk—naked. Cob and tassel almost free from spikelets.
P—pericarp and cob color. An allelomorphic series P^{rrr}, P^{ww}, P^{wr}, etc.
pb—piebald, yellow and green spotted seedling.
pg—pale green seedlings.
Pl—purple plant color.
Pr—purple aleurone.
R—red aleurone. An allelomorphic series, also affecting plant colors and pericarp. R^r, R^g, r^r, r^g, r^{ch}, etc.
ra—ramosa ear.
[a]ru—rugose leaf.
sh—shrunken endosperm.
[a]sk—silkless. No silks on cob.
sl—slashed. Slashed or shredded seedling
sm—salmon silks.
sp—spear. Spear-like seedling. Usually lethal.
st—stippled aleurone.
su—sugary endosperm.
te—tassel ear } Two types producing only pistillate flowers in the
ts—tassel seed } tassel.
Tu—tunicate ear (pod corn).
[a]tw—twisted stalk,
v—virescent seedling.
w—white seedling.
ws—white sheath.
wx—waxy endosperm.
Y—yellow endosperm.
Yp—pale yellow endosperm.
ys—yellow striped leaf.
zb—zebra—transversely striped leaves.
zg—zigzag stalk.
zu—Zuni aleurone (colored caps).

Chlprophyll Factors

Seedlings—
pb—piebald.
pg—pale green.

v—virescent. (*Lindstrom*, 1918).
w—white. (*Lindstrom*, 1918.)

Seedlings and mature plants—
ar—argentia.
f—fine stripe.
l—yellow seedlings with w or v. Yellow striped in mature japonica. (*Lindstrom*, 1918; 1921.)
zb—zebra.

Mature plants—
bl—blotched leaf.
dt—dotted leaf.
fi—fine streaked.
g—golden. (*Lindstrom*, 1918).
gs—green striped. (*Lindstrom*, 1918.)
j—japonica striped. (*Lindstrom*, 1918.)
li—lineate leaf. (*Collins*, 1920.)
pk—dotted leaves.
ws—white sheath.
ys—yellow striped.

Plant and Anther Colors

(*Emerson*, 1921.)

	Plant—	Anthers—
Ia	A B Pl R^r—purple	purple
Ib	A B^w Pl R^r—weak purple	purple
Ig	A B Pl R^g—purple	green
IIa	A B pl R^r—sun red	pink
IIb	A B^w pl R^r—weak sun red	pink
IIg	A B pl R^g—sun red	green
IIIa	A b Pl R^r—dilute purple	purple
IIIg	A b Pl R^g—green	green
IVa	A b pl R^g—dilute sun red	pink
IVg	A b pl R^g—green	green
V	a B pl —brown	green
VIa	a B pl —green (or slight brown in sheaths)	green
VIb	a b Pl —green (or slight brown in tassel)	green
	a b Pl r^{ch}—green (considerable brown in tassel)	green
VIc	a b pl —green.	

Factor r^r has the same effect on plant color as R^g, and r^r the same effect as R^g.

Silk Colors

(*Anderson*, 1921a)

A Sm P—green.
A sm p—green.
A sm P—salmon.
A Sm p—brown.

Colors indicated are of silks under husks. Parts exposed to sunlight may be red if R^r or r^r is also present. P is the factor for red pericarp. With aa all silks are green.

Pericarp Colors and Patterns

(*Anderson*, 1921b)

Cherry pericarp series—	Pericarp color—	Cob color—
A Pl r^{ch}	cherry	purple
a Pl r^{ch}	brownish	brownish
A pl r^{ch}	white	white
a pl r^{ch}	white	white
Red pericarp series—		
A P^{rr}	red	red
A P^{or}	orange	red
A P^{wr}	white	red
A P^{ow}	orange	white
A P^{cw}	white-capped red	white
A P^{vv}	variegated	variegated
A p	white	white

With aa brown color in place of red.

Aleurone Colors and Patterns

(*East*, 1912; *Emerson*, 1918)

i A C R Pr—purple.
i A C R pr—red
i A C r
i A c R
i a C R
i A c r
i a C r
i a c r
} white
I A C R Pr—white.
Bh—blotched. Shows only in A c R Bh.
br—brown. Relation unknown.

in—intensifier.
M—mottled. Shows only in r r R.
st—stippled.
zu—Zuni.

Endosperm Colors

Y—yellow. (*East and Hayes*, 1911.)
Yp—pale yellow. (*Emerson*, 1911.)

Endosperm Texture

Su Wx—(*Collins and Kempton*, 1914; *Kempton*, 1919.)
Su wx—waxy. (*Collins and Kempton*, 1914; *Kempton*, 1919.)
su Wx—sugary. (*Collins and Kempton*, 1914; *Kempton*, 1919.)
su wx—(*Collins and Kempton*, 1914; *Kempton*, 1919.)
Fl Fl fl—flinty. (*Hayes and East*, 1915.)
Fl Fl fl—flinty. (*Hayes and East*, 1915).
Fl fl fl—floury. (*Hayes and East*, 1915.)
fl fl fl—floury. (*Hayes and East*, 1915.)
de—defective seeds. (*Jones*, 1920.)
sh—shrunken endosperm. (*Hutchinson*, 1921.)

Plant Height

Dwarfs and semi-dwarfs—
an—anther ear (variable in height.) (*Emerson* and *Emerson*, 1921.)
bc—brachytic. (*Kempton*, 1920.)
bv—brevis.
cr—crinkly.
d—dwarf. (*Emerson*, 1912b; *Emerson and Emerson*, 1921.)
na—nana.
te—tassel ear. (*Emerson*, 1920)
ts—tassel seed. (*Emerson*, 1920.)
tw—twisted.
zg—zigzag. (*Eyster, W. H.*, 1921a.)

Leaf Characters

cr—crinkly.
gl—glossy.
lg—ligueless. (*Emerson*, 1912a.)
mr—midrib.
ru—rugose.
sl—slashed.
sp—spear.

Ear Characters

d—dwarf. With anthers in the ear.
an—semi-dwarf. With anthers in the ear.
ra—ramosa. Branched ear. (*Gernert*, 1912.)
Fs—fasciated ear. (*East and Hayes*, 1911; *Emerson*, 1912b.)
in—interrupted ear. (*Emerson*, 1912b.)
nk—naked. (*East and Hayes*, 1912.)
sk—silkless.
Tu—tunicate. (*Collins*, 1917.)
te—tassel ear. Zigzag rows in ear due to development of both flowers of the spikelet.
ts—tassel seed. Zigzag rows in ear due to development of both flowers of the spikelet.

Tassel Characters

ad—adherent.
co—coherent.
ms—male sterile. (*Eyster, L. A.*, 1921.)
nk—naked.
ra—ramosa.
Tu—tunicate.
te—tassel ear.
ts—tassel seed.

Linkage Groups in Corn

List furnished by Dr. Lindstrom, of the Iowa Experiment Station.

I, the C group, including also I, sh, wx, v_1, pk.
II, the R group, including also l, S, g, li_1, pg, Pr.
III, the Su group, including also Tu, de.
IV, the B group, including also lg, ts_1, v_4, sk.
V, the Y group, including also Pl, sm, w_1, w_5, $w_6$ms.
VI, the P group, including also br, ts_2, f.
VII, the A group, including also v_3.
VIII, the Bn group, including also gl_1, V_5, ra, pg_3.

CHAPTER XVII

JUDGING AND TESTING FOR YIELDING ABILITY

Corn shows first became really popular about 1890, reaching their crest about 1910. In the early corn shows, the idea was to give the prize to the sample which gave indications of the greatest yielding power. The men who drew up the early score cards assumed that of course high yield was associated with ears as large as the ordinary season would mature, and ears with a high percentage of shelled corn. Therefore, in the central part of the Corn Belt the ideal was an ear 10 inches long, $7\frac{1}{2}$ inches in circumference, with eighteen to twenty-two rows packed together tightly on the cob and carried out over the tip and well-rounded butt. The space between the rows of kernels, both at the cob and on the outside of the ear, was to be as narrow as possible because that meant a higher percentage of shelled corn. Deep kernels, keystone in shape, and moderately wide, met the ideals better than either the narrow shoe-peg kernel or the shallow, extremely square kernel, both of which were thought to be associated with a lower shelling percentage. Ears with straight rows and cylindrical in shape were preferred because the kernels were more uniform and could be planted with fewer skips by the corn planter. Large germs were desired because that meant more oil and protein in the kernel and therefore more feeding value. For probably fifty years before the popular corn shows of the early twentieth century, these common-sense points had appealed to thoughtful corn farmers everywhere, and the men who made out the score cards in the nineties merely reflected the opinions of the men who had thought most about corn.

Corn Judging Development

Fancy points.—About 1900, the corn judges began to prefer corn with a rough dent. The rough dented corn seemed to have straighter rows and more uniform kernels, which also seemed to be a little deeper. It was also advisable to develop fancy points of this sort in order to enable the judges to make any distinction between the hundreds of competing samples, most of which were almost equally good from the standpoint of the original score card. And so it came about that corn judges unconsciously came to think more and more about fancy points.

Tests upset ideals.—The first corn shows were held before the days of careful experimental work. It is not surprising, therefore, to find that actual yield tests with different types of corn rudely upset some of the most cherished ideals of the early corn judges. For ten years the Ohio station continuously selected for moderately long ears of corn and for moderately short, and contrasted the yielding power of the two strains. The short ears, only 6 or 7 inches in length, seemed to have the ability to yield almost exactly the same as the ears 9 or 10 inches long. Bare tipped ears with nearly an inch of cob showing yielded about the same amount of shelled corn per acre as ears with perfectly filled tips. Ears shelling out only 76 per cent yielded considerably more ear corn per acre and fully as much shelled corn as ears shelling 88 per cent. Smooth corn slightly outyielded the rough corn. Carefully conducted tests of this sort at the Ohio, Nebraska and a number of other stations made it appear extremely doubtful if many of the points on the old-fashioned corn score card were worth while from the standpoint of yield.

No one has as yet learned enough about corn to know just what relationship there is between yield and the different ear and kernel characteristics. The relationship seems to be different in different seasons and on different soils. The following yield score card is based chiefly on experimental work in Iowa

and Illinois and probably applies as well as any to central Iowa and Illinois.

Yield Score Card

(No fancy points)

	Points
Solid, well-matured ear which weighs like lead (heavy for its size, with kernels firm on cob; no sign of shredded shank attachments at butt)	25
Length of ear (at least 7 inches)	5
Circumference of ear (at least 5.5 inches)	5
Width of kernel (not less than $\frac{1}{4}$ inch wide)	5
Thickness of kernel (not more than 8 kernels to the inch)	5
Depth of kernel (at least $\frac{7}{16}$ inch deep)	5
Kernels plump at tip coming down broad and thick to the cob	15
Kernels without blistering or damage by mice	5
Kernels with bright, large germ (germ should be clear and waxy when cut)	5
Kernels come loose from cob without leaving tip cap or taking part of cob with them—no evidence of disease or discoloration	15
Kernels with slightly rounding sides and medium to wide space between rows at outside of ear	5
Hard, horny kernels free from starch, lustrous, shining and rather smooth	5
Total	100

It is assumed in this score card, as should be the case with all corn score cards, that ears which will not grow are given no consideration whatever. In Illinois and parts of Iowa where root rot diseases are serious, the last point—hard, horny, shiny kernels free from starch—probably should be given 15 to 20 points instead of only 5, for it has been definitely proved that starchy kernels are more susceptible to these diseases and yield less as a consequence. In Nebraska, especially in the western part, 15 or 20 points should be given to a smooth dent combined with a slender ear and freedom from starchiness. On the other hand, the rich bottom lands of central and southern Indiana seem to yield more when planted to a rough, somewhat starchy corn carrying twenty or even twenty-two rows of kernels,

than when planted to the smaller, slender-eared type with its horny, shiny kernels.

What corn judges like.—While no one knows much about measuring the effect of ear and kernel characteristics on yield, it is fairly easy to learn what type of corn will appeal to corn judges at the big corn shows. In the single-ear classes in the central part of the Corn Belt, the ideal ear is 10 inches long, $7\frac{1}{2}$

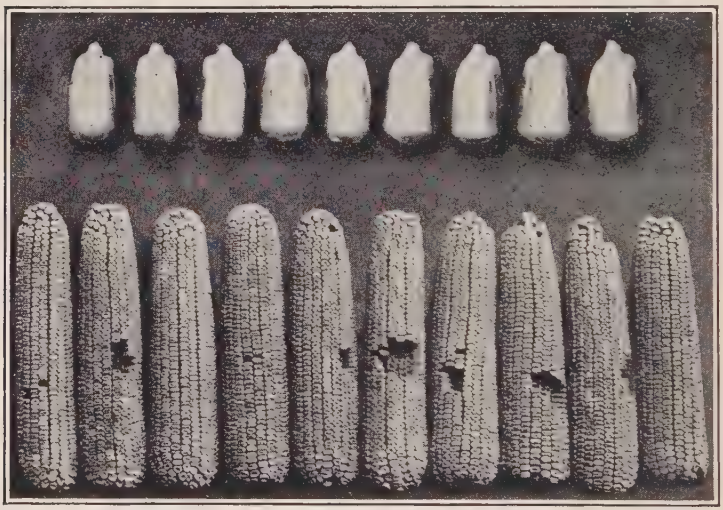


FIG. 81.—This type of ten-ear sample, which represents hundreds of hours of labor picking over thousands of ears of corn, wins at the corn shows. No one can tell in advance whether such corn will yield as much as, or more than, ordinary corn.

inches in circumference, with twenty or twenty-two straight rows of kernels carried out to the tip (tip kernels being of the same type as the kernels on the body of the ear), and with a well-rounded butt with only a small opening left for the shank. Of course, the ear must be straight and cylindrical in shape, with the diameter carried uniformly from the butt to within 2 or 3 inches of the tip, where a slight taper is permissible. The kernels must be moderately wide, keystone in shape, deep,

plump at the tip, and without any trace of being shrunken or blistered. In Iowa and Illinois, the judges lay great emphasis on the backs of the kernels being horny and shiny, but in Indiana and at the International Grain and Hay Show they are not so particular about this point. In central Iowa, Indiana and at the International the custom has been to favor the rough corn, whereas in Illinois, since 1920, they have been favoring the smooth corn with an exceedingly horny kernel, showing the least possible susceptibility to root rot infections. By attending corn shows and associating with corn judges, it is possible to learn their ideals and pick corn to meet them. In the ten-

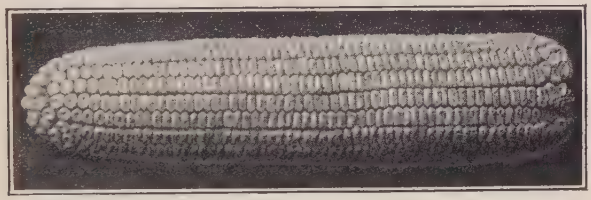


FIG. 82.—An ear of Johnson County White which sold for $250 at Chicago Corn Show. Such an ear may be no more productive than a very ordinary ear.

ear and bushel classes, it is necessary to pay great attention to uniformity. All of the ears should be within an inch of the same length. None of the ears should carry less than eighteen rows nor more than twenty-two. The kernels should all be of the same size, shape and color, showing no trace of mixture with white pollen (if the variety is yellow) or yellow pollen (if the variety is white). In addition, the ears must be true to what the judges recognize as the variety type. To fulfill all of these requirements means that a man must start with seed from a recognized show strain and grow it out on rich soil and then go over 50,000 or 100,000 ears in the hope of finding a prize-winning sample. Picking corn for show is interesting work which appeals to farmers with an eye for the beautiful. The premiums offered

at the corn shows have made corn exhibiting profitable for many men. This has been especially true in central Indiana and the southern half of Iowa, where a combination of rich soil, a rather long season, and favorable rainfall has made it possible to grow beautiful, rough, large-eared corn very easily. Farmers who are interested in yield primarily should pay little attention to the corn shows until they are conducted on a more practical basis.

Shows are in a state of change.—Corn shows seem to be now in a state of change, and in the future the judges may pay somewhat more attention to the practical points and somewhat less to the merely beautiful. The weak point in all corn judging is that most of the really important functions of the corn plant which have to do with yield express themselves in other ways than through the shape of ear and type of kernel.

Corn shows and corn judges have an important place in drawing men of like tastes together, but they are no longer having much direct influence in improving the yield of our corn. The Iowa Corn Growers' Association has to some extent recognized this by inaugurating a scientific yield contest.

Corn-yield Contests

Practical farmers long ago discovered that the corn which won at the corn shows was not necessarily high-yielding corn. It was therefore suggested that farmers compete to see who could produce, not the best looking corn, but the most corn per acre. Such contests demonstrated that it was possible in the South, by means of extremely heavy fertilizing combined with a favorable season, to produce over 200 bushels per acre. On rich clover sod land in the North it was found that occasionally, when all conditions were favorable, more than 130 bushels per acre could be produced.

Ira Marshall of Dola, Ohio, for instance, on exceedingly rich black muck land recently in alfalfa and heavily manured and fertilized with commercial fertilizer, has obtained yields of

157 bushels per acre or better for the years 1925, 1926, and 1927. These yields were on a 10-acre field and were officially verified and corrected to 20 per cent moisture. Mr. Marshall has used the small-eared Clarage variety planted in hills 33 inches apart each way with an average of 3.5 stalks to the hill. This is twice as thick planting as is usual in the Corn Belt and would result in small nubbins if the soil were not very rich, retentive of moisture, and heavily fertilized. It is important also when corn is planted this thickly to have a rather small-eared variety.

Practical farmers in Iowa and Illinois say that they have no time to fool around with a pet acre or a pet 10 acres which will not win a prize unless they get some lucky rains at just the right time in July and August.

As a result, acre yield contests are now used for the most part as a device to interest farm club boys. In this way, these tests have done an immense amount of good, definitely starting many boys on the path of becoming genuinely interested in all that makes for good farming.

Best type of test.—The best type of corn-yield contest involves growing several strains of corn side by side on the same land, to see which sorts will yield the most when all conditions are alike. This type of contest should be conducted for at least three years, and preferably for five. Since practical farmers are not in position to do the careful experimental work involved in this kind of a contest, it has been the custom for the county agent, the experiment station, or the Corn Growers' Association to supervise the planting and weighing. All the farmer who enters this kind of a contest has to do is to furnish a few pounds of seed (in some cases he also pays an entry fee of a few dollars to defray part of the expenses). The farmer has none of the bother of growing or harvesting, but at the finish receives the benefit of knowing how his seed compared in yielding power with other strains of corn grown under exactly the same soil and moisture conditions. If his corn has done well, he may develop quite a seed business. If it has done poorly, he will find it advisable to buy corn from someone whose corn has done well,

growing the two sorts side by side on his own farm at first in order to verify under his own conditions the results of the yield test.

Woodford County test.—The first carefully conducted three-year corn yield contest of this sort was the Woodford County, Illinois, test, which was begun in 1919 and completed in 1921. Seed from 120 Woodford County farmers was entered in this test in each of three years. These 120 sorts were grown side by side in two different places in the county. Every other row across the test field was a check sort not entered in the contest. By correcting the yield by means of the adjoining check, it was possible to take soil variations into account. The Krug strain of Reid Yellow Dent, which stood at the top as an average of the three years, outyielded the average corn in the contest by 6.6 bushels per acre, and the poorest, which was also a strain of Reid, by 17.1 bushels. The ten high yielders were grown again side by side in a number of different places in Woodford County, in 1922, and again the Krug corn outyielded the others.

Iowa yield test.—The Iowa corn-yield contest was begun in 1920 by the Iowa Corn Growers' Association. The Iowa experiment station assists in planting and harvesting the plots of the strains, which are grown side by side under the same conditions. The state is divided into twelve districts with a testing station in each district. Each farmer who enters designates which district his corn is to be grown in. A few farmers enter their corn in several districts, but most of them make only one entry and that in the district in which each lives.

At a testing station, ten replications of three rows each are grown of every sort entered. The plots are all planted by hand so that exactly the same number of kernels will be planted in each one. In the fall, each plot is weighed up separately and samples are taken so that all weights can be reduced to shelled corn of the same moisture content. All of this work is done so carefully that the expense per entry at one testing station is about $4. Each farmer who enters, however, pays only $3, the

other $1 being borne by the Corn Growers' Association and the State of Iowa.

In the early years of the Iowa corn-yield test, most of the highest yields in northern Iowa were Silver King, and in the southern half of the state Reid Yellow Dent. In 1923, however, high-yielding yellow strains were discovered for northern Iowa. For five years these yellow sorts have definitely outyielded Silver King and other white varieties which formerly dominated Northern Iowa. McArthur's Golden King has been especially outstanding in Northern Iowa. In the southern half of Iowa, crosses of inbreds were entered for the first time in 1924, with the result that they took most of the high prizes. Since 1924 the crosses of inbreds have had a definite advantage over the ordinary open pollinated varieties. In north-central Iowa, crosses of varieties as made by George M. Allee have done exceptionally well. Outstanding strains of Reid Yellow Dent brought to light by the Iowa Corn yield-contest are: Black, Krug, Steen, McCulloch, Kirkpatrick, Miller, Clampitt and Osterland. Ioleaming, which is a cross of Leaming and Reid, has done remarkably well in north-central Iowa.

Significance of yield test.—One year of corn-yield testing does not mean much unless the sorts which win have an unusual lead above the average. Three or even five years of testing are necessary if the different kinds are to be subjected to different climatic conditions. The object of a yield test is to find sorts which will yield the most, not in a cold year, nor in a hot year, but in the average run of years. This means that farmers who enter a corn-yield contest should put their corn in for at least three years before they feel sure that their corn has been definitely proved to be good or bad. If their corn proves to be low in yielding power, the next thing is to buy a bushel or two of seed from men whose corn has proved to be of high-yielding power and compare this corn with the home corn under home conditions. After a year or two of this, a farmer may find that

he can make several hundred dollars a year more by using a higher yielding sort of seed corn.

Most farmers never enter a corn-yield contest. In order for them to get benefit out of such a test, the thing for them to do is to buy a little seed each year of men whose corn has yielded well in the test. This high-yielding seed should be planted in the home field in such a way that a fair comparison can be made of the dry yield of the home corn and the so-called high-yielding corn. A number of Iowa farmers have done this and as a result are now several hundred dollars richer each year.

In the future, it is to be hoped that there will be special corn-yield contests for poor land, for early corn and for silage corn. The corn-yield contests, if properly conducted, will bring to light splendid corn material which the inbreeders and cross-breeders can use to develop wonderfully superior combinations.

CHAPTER XVIII

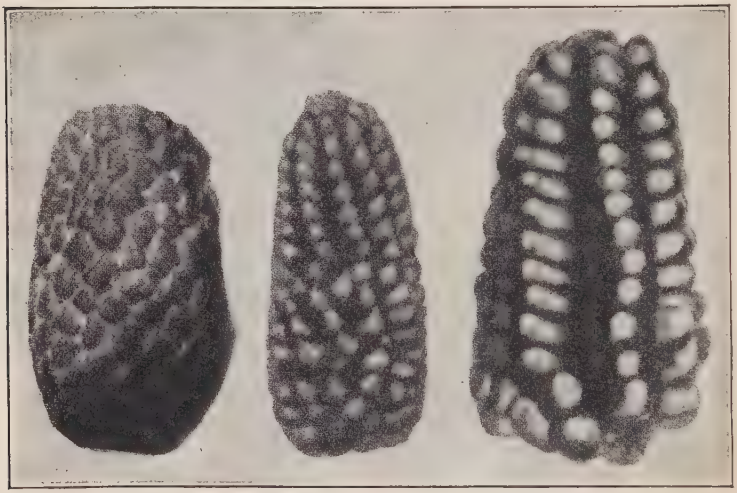
HISTORY AND IMPORTANCE OF CORN

History

Corn is one of the few standard crops that originated in America. Early writers disagreed as to the place of origin of corn, some maintaining that it came from eastern Asia; others that it came from Africa, while still others said it was of American origin. The latter is now generally accepted as the true theory. The main reason for the acceptance of this theory is that no mention is made of corn in the early writings, and, with one possible exception, no mention is made of it until the discovery of America, in 1492. This possible exception is a tradition of the Norsemen that they found the grain being cultivated by the Indians when these explorers landed on the western continent, in 1002. Another reason for the belief that corn originated in America is that it was generally cultivated by the natives when Columbus first discovered the continent. Its antiquity in America is also indicated by the specimens found in the ruins of the Cliff Dwellers and Mound Builders. Highland Peru and southern Mexico are the two places which have the best claim to being the original home of corn. The fossil ear found in 1914 in Peru by Doctor W. F. Parks indicates Peru as the place of origin of corn. The ear, which is doubtless several thousand years old, is much like some of the present-day varieties grown in Peru. The specimen is 3 inches in length, tapered, and rounded on the butt end. The kernels are somewhat like those of rice popcorn.

According to Harshberger, the Indians probably first found

the plant in Mexico, in the region above 4500 feet altitude and south of 20° north latitude and north of the river Coatzacoalcos and in the isthmus of Tehuantepec. It probably reached the Rio Grande about 700 A.D., and by the year 1000 had reached the coast of Maine. These dates are more definite than most writers give, but the evidence of wild grasses related to corn growing in southern Mexico suggests Mexico rather than Peru as the place of origin.



Courtesy of Journal of Heredity.

FIG. 83.—On left fossil ear discovered in Peru and on right modern types of corn as grown in Peru.

Originated from wild grass.—In southern Mexico there are two native wild grasses, gama grass and teosinte, both of which are closely related to corn. Corn has never been found growing wild, and many are of the opinion that corn has been developed from teosinte, which resembles corn more closely than any other wild grass. Other writers think that both corn and teosinte developed many thousands of years ago from a common ancestor, possibly from such a grass as perennial teosinte, recently

found in southern Mexico. Others think that annual teosinte is a cross of corn and perennial teosinte.

Teosinte has a tassel just like corn, and the seeds are enclosed by husks and borne in the axils of the leaves. The teosinte ear (there is no cob) is about 3 inches long and is composed of five to ten kernels arranged end to end. Teosinte readily crosses with corn, which again suggests that the two plants have a common ancestry or that corn originated from teosinte.

FIG. 84.—Teosinte tassel and ears. Teosinte ears have no cob.

Corn and teosinte both doubtless trace back to a plant resembling gama grass, a plant having a tassel at the top and tassel-like structures on long, lateral branches—all tassels bearing male flowers on the upper part of the tassel and female flowers on the lower part. In the process of evolution and diversification, the tassels at the top came to produce only pollen and the tassels on the lateral branches only seeds, and at the same time the lateral branches were shortened until the tassels were enclosed by husks. It is also probable that in this

evolution the lateral tassel developed into an ear. Nature has been aided by man, of course, in the selection of our present types of corn.

Early types of corn.—Most writers speak of flint, soft, gourd-seed and sweet types of corn as being grown by the Indians and the early settlers. Indications are that the dent varieties of to-day are the result of both accidental and intentional crossing of gourd-seed and flint types. This is discussed fully in Chapter XIV.

The Atlantic Coast farmers, from 1800 to 1840, made a real effort to get high-yielding strains of corn. The farm papers of 1819 to 1822 tell of several instances of getting Maha (undoubtedly Omaha Indian) corn from Council Bluffs—now a part of Iowa. This corn was an eight-row soft corn type, and several of the eastern farmers claimed yields of more than 100 bushels to the acre. The Sioux yellow, ten to twelve-row flint corn, was introduced from the West by several growers, and there were several introductions of a Canadian flint corn. These introductions, together with the local varieties, are probably found to some extent in all of our present-day varieties, and help to explain the heterogeneous nature of our present-day types.

In 1836, Lt. A. M. Lea reported: "The large white corn of the South may be produced as far north as Rock Island, and yields from 50 to 100 bushels per acre, but the yellow flint grows well anywhere and yields from 40 to 75 bushels—the latter is the more certain crop."

J. M. Chambers, of Linn County, Iowa, in 1858 wrote: "The yellow flint and the Virginia gourd-seed are the principal varieties."

Early history in America.—Early explorers in America mention the large fields of corn cultivated by the Indians, and remarked about the slowness of Europe to adopt this new grain, which they considered to be so valuable. Columbus first saw corn on November 5, 1492, on the island of Cuba. In 1498, Columbus reported his brother as having passed through eighteen miles of corn on the Isthmus; in 1605, Champlain saw a

field of corn at the mouth of the Kennebec river; in 1609, Hudson saw many fields along the Hudson river, and in 1620, Captain Miles Standish reported a field of 500 acres in Massachusetts that had been cropped the year previous. Drawings made by Hernandez of corn which he found in Mexico about 1600 show the plant with three or four ears on the stalks, and ears with eight or ten rows.

Thomas Hariot, a member of the ill-fated Virginia colony of 1585, wrote in 1588 what is probably the first extended English description of corn as grown in what now is the United States. He stated: "Pagatour, a kinde of graine so called by the inhabitants; the same in the West Indies is called Mayse. . . . The graine is about the bignesse of our ordinary English peaze, and not much different in forme and shape, but of diuers colors; some white, some red, some yellow, and some blue. All of them yeelde a very white sweete flowre; being used according to his kind it maketh a very goode bread."

On November 16, 1620, a group of Pilgrims landed on the Plymouth coast and spied five Indians whom they followed all that day. The next morning, they "found new stubble where Indian corn had been planted the same year." Near a deserted house "heaps of sand newly paddled with hands which they digged up and found in them divers fair Indian corn in baskets, some whereof was in ears, fair and good, of divers colors, which seemed to them a goodly sight having seen none before."

The most important history of corn in this country, as far as the white man is concerned, began with the settlement of Jamestown in 1607. The colonists had a hard time to keep from starvation; and had it not been for the corn obtained from the Indians, the colony would probably have resulted in failure. The Indians taught the colonists how to prepare the ground and plant the corn. The trees were girdled, the ground stirred and the grain planted in hills three or more feet apart. In places on the New England coast, it was necessary to fertilize the ground before it would produce a crop. The Indians showed the colonists how to fertilize with fish. Herring or shad,

which came up the streams by the thousands in the spring to spawn, were caught; and one fish was placed in each hill of corn. One writer of the time said that it took about a thousand fish to plant an acre of corn, and without fish no corn was planted. He also stated that an acre of corn planted with fish yielded as much as three acres planted without.

Corn formed such an important crop with these colonists that many laws were passed regulating the minimum amount to be grown and the methods of caring for it. It was even enacted that all dogs should be tied by the leg during planting time, to prevent their eating the fish. Other laws were passed providing for the payment of taxes in corn. The price when used for this purpose was fixed by law. One writer of the time says that the reason so much corn was grown rather than wheat was because wheat would not grow and mature. The failure of wheat was, of course, due to the growing of unacclimated English varieties.

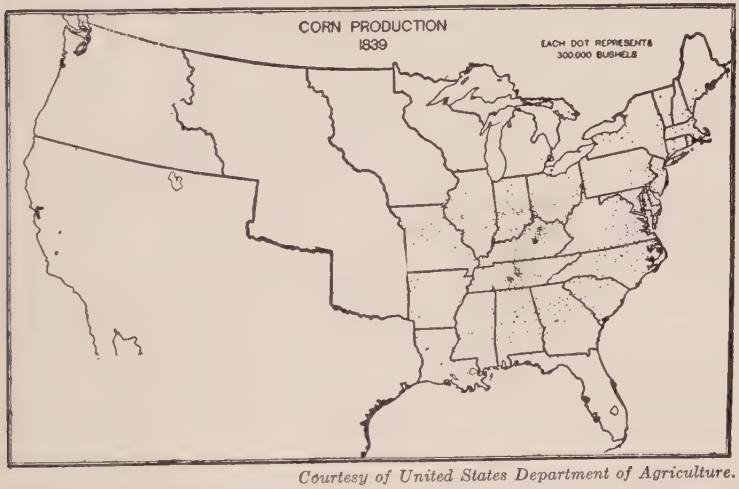
The cultivation of corn in America increased rapidly. In 1609, it is reported that thirty acres were planted. In 1650, there is a record of 600 bushels being exported from Savannah, and from that date on there were exports from the colonists almost annually. In 1770, the total exports were 578,349 bushels, and in 1800 this was increased to 2,032,435 bushels.

Later history in America.—With the opening of the Mississippi valley, the production of corn increased by leaps and bounds. The growers found that corn was peculiarly adapted to this region, and it at once became the principal crop. This section soon became world-famous as the "Corn Belt." About 1870 began the increased use of farm machinery and improved varieties of corn so that a man could tend a much larger area and at the same time obtain larger yields. The 1839, 1859 and 1919 maps of corn production in the United States illustrate very vividly how recently the Corn Belt has come into its own.

Schmidt says that during the fifty-year period from 1849 to 1899 the center of corn production moved north only five miles, whereas at the same time the center of production had moved

westward 480 miles. The center of corn production is now near the Mississippi River, not far from Keokuk, Iowa.

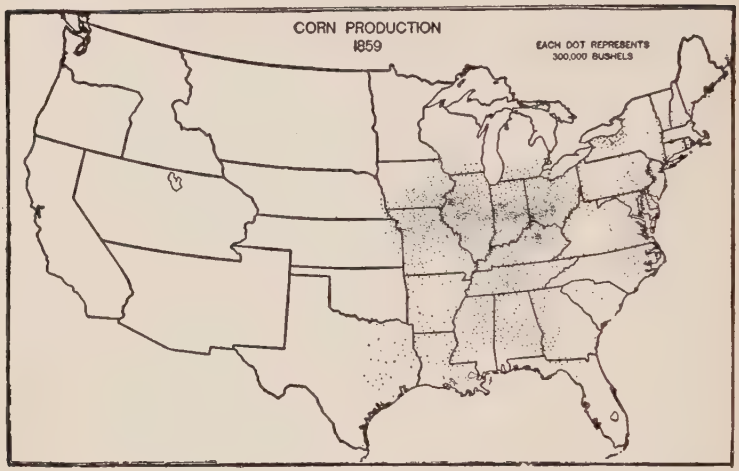
History in the Old World.—Soon after the New World was discovered, corn from the West Indies and Peru was introduced into Spain, Italy, southeastern Europe, India, Africa and China. During the sixteenth century corn growing spread with exceeding rapidity over the temperate and sub-tropical



Courtesy of United States Department of Agriculture.

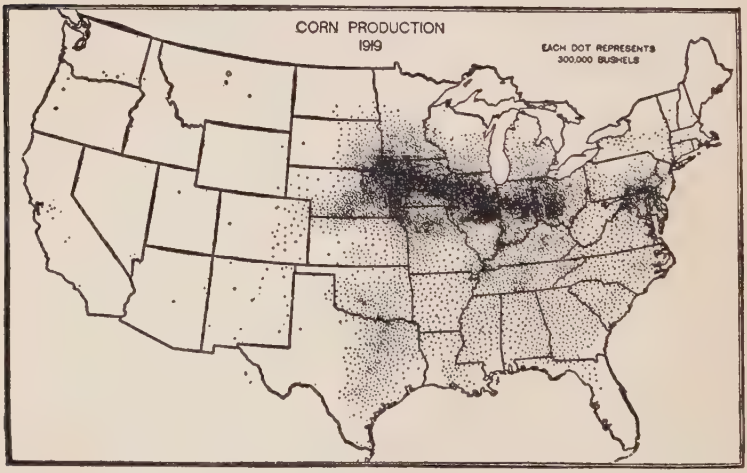
FIG. 85.—In 1839 Tennessee and Kentucky were the leading corn states and the total production of the entire United States was less than the normal crop of Iowa to-day.

regions of the entire world. In no place, however, with the possible exception of a rather limited area in the Balkan states, did corn come to dominate the entire agriculture of a region as it does in the Corn Belt of the United States. Much of the corn grown in Europe has descended from the tropical flints of the West Indies. In the nineteenth century, however, a few Corn Belt varieties were introduced into Europe, but, generally speaking, corn as grown in the Corn Belt has met with very little favor anywhere outside of the Corn Belt, the one outstanding



Courtesy of United States Department of Agriculture.

FIG. 86.—From 1839 to 1859 the center of corn production moved north and west and the Corn Belt as we now know it began to take shape. Illinois and Ohio were the leading corn states in 1859.



Courtesy of United States Department of Agriculture.

FIG. 87.—In 1919 Iowa was the first corn state and the center of corn production was not far from Keokuk, Iowa.

exception being Australia. For further information concerning corn outside of the Corn Belt, see Chapter XIX.

Importance of Corn

Value in the United States.—The value of corn in the agriculture of the United States is well known. In acreage, in multiplicity of uses, in production and in value, it exceeds any other cultivated crop. In recent years the acreage devoted to corn in this country has been slightly greater than the combined acreage of the crops of wheat, oats, barley, rye, rice, buckwheat and flax. The value of the corn crop in the United States exceeds the combined values of these crops by 20 to 30 per cent.

Eventually, the manufacture of corn products in the United States will equal or exceed the meat-packing industry. Even now, more than 60,000,000 bushels of corn every year are used in the manufacture of such products as starch, corn syrup and corn oil. Corn is one of the greatest potential sources of the alcohol which will doubtless be needed to run our automobiles when eventually the crude petroleum supply is exhausted.

Valuable as a sustainer of life among primitive peoples in peace and war, corn, ever since the early days of the Jamestown and Plymouth colonies, has bulked large in the white man's existence on this continent. There is no indication that it will ever be otherwise.

Value in the Corn Belt.—Corn is the basis of wealth in the agricultural region known as the Corn Belt—Iowa, Illinois, Ohio, Indiana, eastern Nebraska, southeastern South Dakota, northern Missouri, southern Minnesota and northeastern Kansas. One hundred and forty million acres of the richest land in the world lie in this Corn Belt of the United States, of which Davenport, Iowa, is not far from the center of production. As may be judged from the map on p. 256, the Corn Belt extends about 100 miles west into Nebraska, 75 miles northwest into South Dakota, 50 miles north into Minnesota and eastward through Iowa, the northern two-thirds of Illinois, Indiana and

the western half of Ohio. This region is the Corn Belt as it exists in the third decade of the twentieth century. As time goes on, it may shift a little to the northwest.

Of the 140,000,000 acres in the American Corn Belt about 85,000,000 acres are plow land, and of this plow land about one-half, or 45,000,000 acres, are put into corn. Roughly, 20,000,000 acres are in tame grass meadow and 20,000,000 acres in oats and wheat.

It is corn that enables these middle-western states to produce such a surplus of pork and beef. The good homes, high land values, and prosperity of the Corn Belt are a direct outcome of the wealth that the corn crop brings to this region. The corn crop of the Corn Belt is the world's greatest bulwark against famine. In times of need, a part of the crop may be diverted from its customary use as an animal food to its more economical use as a human food.

During the spring, summer and fall, the Corn Belt farmer spends nearly three-fourths of his man and horse labor on corn. He puts twice as much time on this crop as on all of his other crops together. Corn is at the center of Corn Belt agriculture. Wheat, oats and hay are grown chiefly to rest the land in preparation for more corn and to use farm labor at seasons of the year when it cannot be employed in growing corn.

The Corn Belt farmer feeds nearly half of his corn to hogs. It is only in rather limited areas, as in central Illinois and parts of northwestern Iowa, that it is customary to ship the greater part of the corn to market in the form of grain. In all sections, one-sixth to one-fourth of the crop is kept at home to feed to horses. This part of the crop is, in a sense, just as much fuel as the gasoline used to run a tractor. Roughly, one-fifth of the Corn Belt corn is sold in the form of fat cattle, dairy products, chickens and eggs. For decades to come, the greater part of the corn of the Corn Belt must be sent to market in the form of livestock or livestock products. But after the population of the United States passes 150,000,000, there will be an ever-increasing per-

centage of corn consumed by people and a smaller percentage consumed by fat cattle and fat hogs.

The Corn Belt of the United States is the only place in the world where there is such a large area of fertile land favored by a rainfall of 10 to 18 inches during the four months following corn planting and an average mean temperature during the thirty days centering around tasseling time of 70 to 80°. The only close approach is in north-central Argentina, in the provinces of Buenos Aires, Santa Fe, Entre Rios and Cordoba. And in this possible corn belt of Argentina, winter wheat, alfalfa and flax are so profitable and the chance of devastating summer drouth is so great that there probably never will be more than 60 per cent as much corn grown as in the American Corn Belt.

CHAPTER XIX

COMPETING CORN-GROWING REGIONS

The outstanding corn-growing areas of the world are characterized by a mean temperature of 56 to 70° at planting time, a mean temperature of 67 to 81° at tasseling time, a rainfall of at least 5 inches, one year with another, for the fifty-day period centering around tasseling time, and a soil moderately rich and fairly easy to cultivate. In the best corn-producing sections of Iowa and Illinois, the mean temperature at planting time is around 61° and at tasseling time around 75°; the rainfall averages about 8 inches, one year with another, during the fifty days centering around tasseling time, and the soil is unusually rich and easily cultivated. There are very few large bodies of land in the world which possess the same combination of factors so favorable to corn as the Corn Belt. Some of the other corn-growing sections are described in the following.

Corn Growing in the Cotton States

Probably more corn is produced in the cotton states than any other one section outside of the Corn Belt. Ordinarily, about 35,000,000 acres are planted in these states, as compared with about 45,000,000 acres in the Corn Belt. Because of poor soil, however, the yield averages less than 20 bushels per acre, and the total output of corn in the cotton South is less than half as much as in the Corn Belt. Nearly all of the corn raised in the cotton South is consumed at home. Practically none of it reaches such primary markets as Kansas City, St. Louis and Chicago.

From one-fourth to one-third of the improved land of the cotton states is put into corn. Cotton has first place in the eyes of the Southern farmers, but corn is a close second.

In such cotton states as South Carolina, Georgia, Mississippi and Louisiana, the corn is generally planted during March or early April, but may be planted as late as June or even July. Plowing is quite generally done with a middle-buster, which is a double mold-board plow substantially the same as a lister, but with no planting attachment. In some sections, especially the western part of the Cotton Belt, the corn is listed in the same way as in Nebraska and Kansas, but in poorly drained districts it is planted on top of the ridges thrown up by the middle-buster. Listing seems to be growing in favor except in sections where the rainfall is heavy and drainage is poor. One-horse planters are quite commonly used in the South. Occasionally in the South they plow and use a two-row planter set to check, but this is the exception rather than the rule.

FIG. 88.—An extreme example of southern prolific corn.

The rate of planting in the South is usually only about one-half as thick as in the North, except on rich bottom lands. On exceptionally poor soil, the rows may be spaced 6 feet apart and the kernels 2 feet apart in the row.

Cultivation is much the same as in the North, but much of it is with single-horse cultivators. In parts of the South, considerable hand hoeing is done at the rate of about two acres a day.

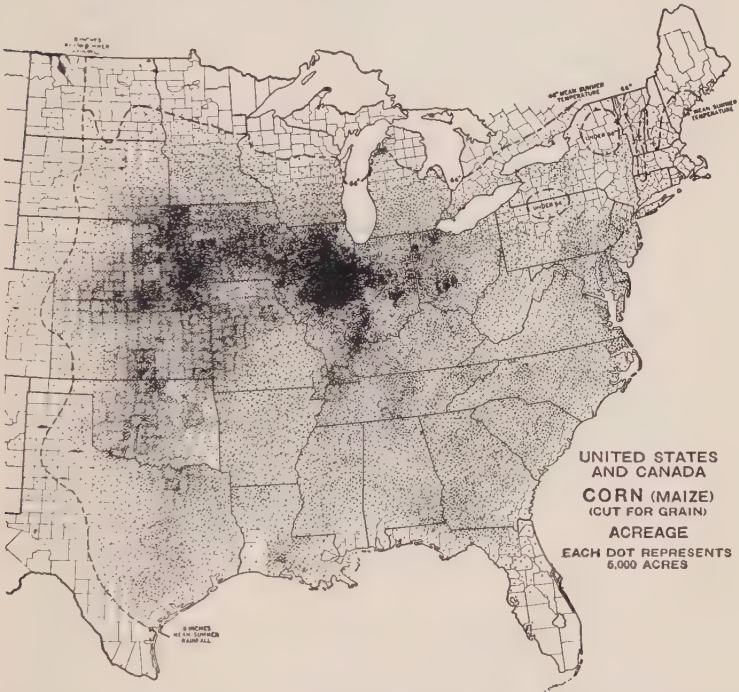
Because many of the soils are poor, corn is more often fertilized in the Cotton Belt than it is in the Corn Belt. A mixture which often gives very good results is 100 pounds of super phosphate and 200 pounds of cottonseed meal, applied either at the time of planting or just before the corn is planted. Sometimes 50 or 100 pounds of muriate of potash are added to this mixture.

The Southern corn root-worm is a very serious pest in the South, and often very severely damages the corn planted in March and early April. Especially is this true in cold, wet seasons. Corn planted in May ordinarily is not bothered. On well-drained land, where this pest usually causes but little trouble, it seems to be the best policy to plant in March or early April.

Throughout the cotton states, the prolific varieties which average nearly two ears to the stalk and oftentimes as many as three, are far more popular than the single-ear varieties which are almost universally grown in the Corn Belt. The ears of these prolific varieties are only about three-fourths as large as the ears of the single-ear sorts, but under Southern conditions, the average prolific plant yields about 15 per cent more than the average plant of the single-ear type. The typical ear of prolific corn carries twelve or fourteen rows and the kernels are rather flinty with a very smooth dent. The husks of well-bred Southern varieties fit tightly to the corn and carry out well past the tip, this husk protection being valued in the South because of the corn ear-worm and weevil, which cause very severe damage to varieties with loose husks.

Climatic conditions in the cotton states are quite favorable to corn, although the weather is frequently too dry at tasseling time for the best results. The rainfall is usually sufficient to produce an abundant crop, and the cotton states would undoubtedly be another Corn Belt if the soil were only richer. As it is, nearly all of the records of corn yielding over 200 bushels per

acre have come from the South, such results being obtained by planting corn thickly on land heavily fertilized. The corn yields of the South will increase in the future as the South grows more soy beans, cowpeas, velvet beans, crimson clover, peanuts



Courtesy of United States Department of Agriculture.

FIG. 89.—Compare this map with the maps of the Argentine Corn Belt and the European Corn Belt. In each case, the dots represent 5000 acres. In the United States, as in Argentina, very little corn is grown where the summer rainfall is less than 8 in. Note that corn is grown uniformly in the cotton states, but that the density of corn planting is not equal to that in the corn belts of Argentina and Europe.

and livestock. As long as the cotton states plant over 33,000,000 acres of land to cotton every year, it is doubtful if they will ever produce much more than 20 bushels of corn per acre on the average.

Corn Growing in Argentina

The Argentine Corn Belt is located about six hundred miles nearer the equator than the American Corn Belt. At planting time, in November (some corn is planted as early as late September and some as late as December), the temperature is usually about 5° higher than in the Corn Belt during May. At tasseling time, in January, the temperature is about the same as in the Corn Belt of the United States. The rainfall during the fifty days centering around tasseling time averages about the same as in our Corn Belt, but there is a little greater danger of really severe drouth. Moreover, there is occasional severe damage caused by the langosta (a grasshopper), which comes in droves from northern Argentina and southern Brazil. The soil is deep and exceptionally rich.

Year by year, since 1909, the acreage, the average acre yield (in bushels), and the exports from Argentina (in bushels), have been as follows:

	Average Acre Yield	Acreage (000 omitted)	Exports (000 omitted)
1909	24.3	7,349	89,499
1910	23.7	7,425	104,727
1911	3.5	7,945	4,923
1912	35.2	8,456	190,351
1913	20.9	9,464	189,328
1914	25.5	10,260	139,458
1915	31.3	10,386	170,488
1916	16.3	9,928	113,140
1917	6.5	8,969	35,190
1918	19.6	8,715	26,170
1919	27.0	8,252	97,850
1920	31.3	8,184	173,642
1921	28.5	8,090	111,603
1922	24.0	7,344	112,553
1923	22.4	7,851	122,875
1924	32.7	8,465	128,313
1925	26.4	8,465	158,625
1926	35.6	9,061	142,956
1927	.....	.....	272,000

Corn production in Argentina from 1911 to 1922 averaged 200,000,000 bushels, and the exports averaged 113,000,000 bushels. Argentine livestock apparently consumes on the average about 85,000,000 bushels annually, or less than half the crop, whereas in the United States livestock consumes about 80 per cent of the crop. The great barriers to increased livestock consumption of corn in Argentina are the splendid alfalfa pastures and the fact that occasionally, as in 1911 and 1917, the crop is almost an entire failure. In such years, a livestock industry built on corn suffers the greatest inconveni-

FIG. 90.—Corn shelling in Argentina.

ence. The possibilities of Argentina as a pork-exporting nation are a little uncertain as long as there is the probability of almost complete crop failure once in every ten years. In this respect, Kansas and Argentina are much alike.

Argentine corn is planted in rows about $2\frac{1}{2}$ feet apart, with the stalks about 15 inches apart in the rows. American listers are much in favor in the southwestern part of the Argentine Corn Belt. A three-row corn planter is used in some sections, but it is set to drill rather than check. Some of the more backward farmers broadcast their corn and plow it under. Argentine corn is not cultivated as much as American corn. Corn husking is at its height in April, May and early June. The corn is husked into baskets about the size of large waste baskets,

and then poured into large sacks, and the sacks are dragged to the edge of the field, where they are picked up with a team and wagon, and the corn is hauled to a crib the sides of which are made of cornstalks. Many of these are round and much like the temporary, uncovered fence cribs seen here and there in the Corn Belt.

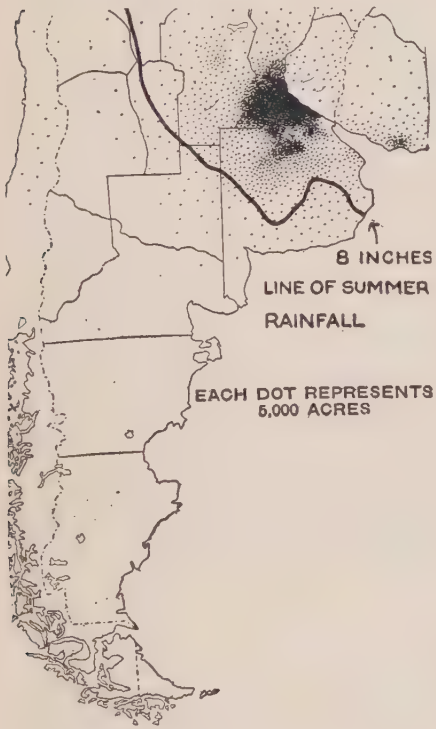
Much of the surplus corn is shelled on the farm and shipped by rail to Rosario (the Chicago of Argentina), which is about

FIG. 91.—The Argentine troje (corn crib) has sides made of cornstalks.

two hundred miles away from the typical farm. Rosario is an ocean port, and the cost of shipping from Rosario to either New York or Liverpool is usually slightly less than the cost of shipping from Chicago to New York. The Argentine farmer really has lower transportation costs separating him from most of the big markets of the world than the American farmer.

The most popular Argentine corn is the Canario, a twelve-rowed yellow flint with ears 7 or 8 inches long. The Piamontese and Colorado are almost equally popular and are very similar

except that the yellow color is so deep as to suggest a tinge of red. The Casilda No. 12 as developed by the Casilda Agricultural School near Rosario from the Piamontese Corn is becoming increasingly popular. The kernels of Argentine flints are much smaller and shinier than the kernels of New England flints. In 100 pounds of dry corn, the Argentine flints typically carry $1\frac{1}{2}$ to 2 pounds more of protein, one-half pound more of fat, and 2 pounds less of starch than our Corn Belt dents. Argentine shelled corn often weighs 60 pounds to the bushel and occasionally as much as 64 pounds.



Courtesy United States Department of Agriculture

FIG. 92.—Argentine corn production is centered in northern Buenos Aires, southwestern Entre Rios, southern Santa Fe and southeastern Cordoba. Very little corn is grown southwest of the 8-in. line of summer rainfall. Rosario, the Chicago of Argentina, on the River Plata, is a port for ocean-going vessels and is located in the center of densest corn production.

The stalks of Argentine flints are very sturdy and decidedly wind resistant. The ears have large shanks and close-fitting husks and are much harder to husk than Reid Yellow Dent. Argentine varieties are apparently well adapted to machine husking. Ordinarily, the Argentine varieties yield about

three-fourths as well as Reid Yellow Dent on the same land.

In Argentina there are about 18,000,000 acres of alfalfa, 14,000,000 acres of wheat, 8,000,000 acres of corn, 4,000,000 acres of flax and 3,000,000 acres of oats. It is possible for Argentina to put about 25,000,000 acres into corn year after year, but it is not likely that this will be done until they have a different type of corn farmer. The Argentine corn farmer is typically a share renter (chacarero), who lives in a hovel and keeps no livestock. He ordinarily handles one hundred acres of corn and nothing else. A man of this sort will not give corn the intensive care that will enable it to compete effectively with wheat and alfalfa for the use of the land.

During the five-year period before the War, Argentina furnished about 50 per cent of the corn which moved across international boundaries. The Danube basin in southeastern Europe furnished about 30 per cent, and the United States about 15 per cent. Because Argentine corn is found to such an extent on the world market, it is worth while studying the Argentine corn situation with some care.

Corn Growing in the Danube Basin

In the Balkan States, Hungary and Bessarabia is located the European Corn Belt. The total acreage is about 17,000,000 acres, or about as much land as is put in corn in Iowa and Missouri put together. Since the peace treaty, half of this corn land is in Greater Rumania. The yield is typically around 20 bushels per acre, with occasional years of failure when the yield is only 10 bushels. The summer temperature averages about three degrees less than in central Iowa and Illinois. The annual rainfall is about 20 inches, or about the same as western Nebraska.

Drouth, insects, floods, and hail often cause severe damage. Corn is customarily grown in rotation with wheat, moderately early flint varieties being preferred, so that they can be gotten

off in time to seed winter wheat. The flints seem to be largely of the twelve-row, small seeded type, somewhat similar to the Argentine flints. In large sections of the Balkans the farmers broadcast the corn in April and plow it under, and then when the corn and weeds are about 3 inches high they go through with a large hand hoe and cut out the weeds and surplus corn and hill up the earth around each plant. Very few corn planters are used, even on the larger estates where scientific methods of growing wheat are general. Where the land is plowed before

Courtesy of United States Department of Agriculture.

FIG. 93.—In this map, as in the Argentine and United States maps, one dot equals 5000 acres. Most of the European corn is grown in the Danube region and in northern Italy. The European corn belt centers around latitude 48, or farther away from the equator than either the United States or the Argentine corn belt.

planting, the customary method of planting is to drop by hand into holes made with a pointed stick.

The corn is quite commonly harvested by cutting the stalks off with a hoe and finally husking and storing in a crib made of woven saplings and thatched with straw.

In Hungary, the methods are possibly a little better than this, but on the whole the Danube corn is produced by peasants who know nothing about modern methods of corn growing. A

large part of the Danube corn crop, which is not exported, is consumed by the peasants, the per capita consumption being about 12 bushels, or probably higher than that of any other part of the world. The extent to which the Danube corn is eaten by human beings may explain why the small-seeded flints are so extensively grown.

Before the War, the surplus Danube and Argentine corn quite largely determined corn prices at Liverpool, Amsterdam and Hamburg. Dent corn from the Corn Belt of the United States occasionally had some influence in years of exceptionally large crops.

Corn Growing in Mexico

Mexico, the original home of corn, grew until 1912 a larger acreage than any other nation aside from the United States. A large percentage of the crop land of southwestern Mexico is put in corn. The yield is low and the crop is consumed entirely at home by people (in the form of tortillas) rather than by animals.

Corn in Western Europe

Italy with 4,000,000 acres, Spain with 1,500,000 acres, and southern France with 1,000,000 acres are the chief corn-growing countries of western Europe. The small-seeded flints are in greatest favor. Much of the Italian corn is grown under irrigation. The crop is used chiefly as human food by the peasants. All of western Europe put together produces less than half as much corn as Iowa. Italy, the leading corn country of western Europe, imports several million bushels annually.

Corn Growing in Asia and Africa

Nearly 100,000,000 bushels are grown every year in India, but it is all consumed at home. Considerable corn is also grown in China. Corn in Asia is infected with a serious mildew disease which has not yet reached the United States.

Egypt grows on her fertile irrigated Nile soil about 60,000,000 bushels annually, but none of it leaves the country.

The negro tribes of interior Africa have grown considerable corn for home consumption for several centuries. There is no prospect, however, that any part of Africa, aside from southeastern South Africa, will ever produce much corn for export.

South Africa.—In the southeastern part of South Africa is a large section of land about a mile above sea level where the season is long and the summer rainfall is just right for corn. The temperature is ideal except that during the middle of the summer it averages around 68°, or about 4° too low. The chief drawback is a rather poor soil. Nevertheless, wonderful progress in corn growing has been made since 1900, and there is a possibility that South Africa may rank eventually with Argentina and the Danube basin in providing western Europe with corn. The favorite South African variety is Hickory King, a large-seeded, late-maturing, twelve-row dent, which is also popular on the poorer soils of the northern edge of the Cotton Belt. Another favorite sort is a variety developed from the Champion White Pearl.

Modern corn-growing methods are employed in South Africa and some very good English and Boer brains are continually at work on the problem of increasing South African corn production. The South Africans seem to have their eyes fixed quite firmly on the export market. The export trade has been built up on the large, flat white kernels characteristic of Hickory King.

CHAPTER XX

COST OF CORN PRODUCTION

In the best corn sections of Iowa and central Illinois, where gang plows and five-horse teams are used, an acre of corn requires about 16 hours of man labor and 42 hours of horse labor. This divides up roughly as follows: plowing, 2 hours of man labor and 10 hours of horse labor; disking and harrowing, 2 hours of man labor and 8 hours of horse labor; planting, $\frac{3}{4}$ hour of man labor and $1\frac{1}{2}$ hours of horse labor; cultivation, 5 hours of man labor and 10 hours of horse labor; husking from standing stalks, 5 hours of man labor and 10 hours of horse labor; spreading manure, $1\frac{1}{4}$ hours of man labor and $2\frac{1}{2}$ hours of horse labor.

Costs in different sections.—In large parts of Nebraska, where the land is very level and the fields are large, and where plowing and planting are done at the same time by means of the lister, an acre of corn requires only about 14 hours of man labor and 38 hours of horse labor. In Indiana, however, where the fields are smaller, and where the combination of heavy spring rains and a clay soil make plowing and disking more difficult, an acre of corn husked from the standing stalks may require as much as 24 hours of man labor and 58 hours of horse labor. In the eastern part of the Corn Belt, because of the smaller fields and smaller farms, gang plows and five-horse teams are not as generally used as in the western part of the Corn Belt. In the husking operations, also, they tend to cling to the old-fashioned husking peg instead of adopting the somewhat more speedy husking hook.

Share tenant's cost of production.—The cost to the share tenant of producing an acre of corn in the central part of the Corn Belt is the value of the man labor plus the cost of the horse labor plus the cost of the machinery. With hands getting $51 a month and board, it may roughly be figured that the cost of an hour of man labor is around 34 cents. The cost of an hour of horse labor is roughly equivalent to the value of 0.1 of a bushel of oats plus 0.1 of a bushel of corn plus 5 pounds of hay, or with corn at 70 cents a bushel, oats at 40 cents a bushel and hay at $16 a ton, it may be said that the cost of an hour of horse labor would be around 15 cents. With values as just stated, a share tenant in the central part of the Corn Belt would invest in his acre of corn about 16 hours of man labor at 34 cents an hour, or $5.44 and 42 hours of horse labor at 15 cents an hour, or $6.30, making a total cost of $11.74 an acre for man and horse labor.

Machinery, seed, overhead and miscellaneous items have averaged about $4 an acre since 1921, or if we credit $1 an acre for the pasture value of the stalks, a net of $3.

Adding $3 to the $11.74, we get $14.74 as the total cost to the share tenant of producing an acre of corn when hands are getting $51 a month and board, and when horses are eating corn worth 70 cents a bushel, oats worth 40 cents a bushel and hay worth $16 a ton. In return for his investment of $14.74, the share tenant gets half the corn crop. If the yield is 40 bushels an acre, as is usual in the best parts of the Corn Belt where this method of renting is most commonly found, the cost of producing a bushel of corn, so far as the share tenant is concerned, is $14.74 divided by 20, or 73.7 cents. With a 30-bushel crop, the cost to the share tenant would be 98.3 cents and with a 60-bushel crop 49.6 cents a bushel.

This would be on the assumption that there is no more labor involved in the large crop than in the small crop. As a matter of fact, the husking charge varies directly with the size of the crop, and taking this into account, the cost to the share tenant of a 30-bushel yield of corn would be only 95 cents instead of

98.3 cents, and of the 60-bushel yield, 54 cents instead of 49.6 cents. These costs are for ear corn in the crib in December.

Owner's cost of production.—The farmer who owns his land has all the expenses of the share tenant plus the taxes and the interest on the investment in his land. If he paid $140 an acre for his land, he has, at 5 per cent, an interest charge of $7.00 an acre; in addition there is probably a tax of at least $1.50 an acre, and $1.50 an acre for miscellaneous overhead charges, making a total of $10.00 an acre. Adding $10.00 and the $14.74, which represents the man labor, horse labor and machinery charge, gives a total of $24.74. With a yield of 40 bushels per acre, the cost per bushel of No. 4 new corn would be 61.8 cents.

This represents the cost of the corn in the crib in December, and makes no allowance for shrinkage. If the corn is to be held until the following summer, the shrinkage, which on the average amounts to about 16 per cent, plus the interest on the value of the corn, will raise the cost by about 13 cents a bushel, or make a total of about 75 cents. If the corn is then to be shelled and hauled to market, there will be an additional cost amounting to at least 4 or 5 cents a bushel.

Reducing costs.—There is no easy way of reducing corn production costs. In sections where the fields are large and level, production costs can generally be reduced several cents a bushel if gang plows are substituted for sulky plows and two-row cultivators for the ordinary single-row. In some sections it may be possible to reduce costs by substituting tractor plowing for horse plowing. Some of the tractor people who use the tractor for corn cultivating as well as plowing, disking, harrowing and planting, have carried an acre of corn up to husking time with the expenditure of only 3 hours of man labor and 3 hours of tractor labor. This contrasts with 10 hours of man labor and 30 hours of horse labor for doing the same work in the ordinary way. Of course, the tractor was used with a four-row cultivator and the job of cultivating the first time over may not have been quite as good as with the single-row, horse-drawn culti-

vator. The tractor is worth while watching, however, as a means of reducing labor costs on large, level farms.

Tractors pulling a three- or four-row corn planter and a three- or four-row cultivator are rapidly coming into use in the northwestern part of the Corn Belt. Tractors of this sort are also used to pull corn-picking machines. The final net gain depends on how well the operator understands and likes machinery and how large and level are the cornfields.

More labor put on the cornfield before planting in the way of disking or harrowing in late April or early May seems often to increase yields and make later cultivation less necessary. The frequent use of the rotary hoe or the weeder during late May and early June has reduced production costs in many cases.

As a rule, however, the methods commonly used in a locality are so well adapted to the situation that it is difficult to make any change in the machinery which will result in a saving of more than 3 or 4 cents per bushel.

Land-owning farmers can reduce production costs most effectively by rotating crops, applying lime and phosphate, and spreading manure. Improving the productive capacity of the soil by 10 bushels per acre will ordinarily do more than anything else to reduce production costs.

One of the simplest ways of lowering corn production costs is to use the highest-yielding variety possible. In every locality there are farmers growing varieties which yield 5 or 10 bushels per acre less than the better sorts would yield on the same land. Every two or three years it is good practice to buy a bushel of seed corn which has a reputation for high-yielding power in order to compare it side by side with the home corn.

Another possible way of reducing costs is to save 5 hours of man labor and 10 hours of horse labor per acre by using hogs to do the harvesting. With man labor at 34 cents an hour and horse labor at 15 cents, this will reduce the cost per acre by about $3.20, or, roughly, 8 cents a bushel. However, hogs during late September, October and November can utilize only a limited

acreage to the best advantage in this way. In wet falls, unfortunately, the hogs waste considerable corn. See Chapter II for further discussion.

When corn-husking machines are further perfected, and especially when varieties are developed which are adapted to the corn-husking machine, it may be possible by making an investment of several hundred dollars in a husking machine to save much of the man labor required in husking.

Cost of Producing Silage

Silage corn as grown in the Corn Belt requires the same man and horse labor per acre up through the time of the last cultivation as ordinary corn, or, roughly, 10 man hours and 30 horse hours. At 34 cents an hour for man labor and 15 cents an hour for horse labor, this amounts to $7.90. The labor at silo filling time varies considerably with the distance of the field from the silo, but averages per acre about as follows:

	Man Labor	Horse Labor
Cutting with binder	1.7	5.1
Loading bundles	.4	.9
Hauling from field and unloading	7.0	14.0
Running engine and cutter	3.0	
Packing in silo	2.9	
Total hours per acre for corn cutting and silo filling	15.0	20.0

At 34 cents an hour for man labor and 15 cents an hour for horse labor, the labor charge for silo filling operations would be $8.10 per acre. The total labor of growing an acre of silage corn, in the center of the Corn Belt, is about 25 hours of man labor and 50 hours of horse labor, or, with prices as mentioned, a total labor charge of $16.00. The interest and depreciation on the

silo is roughly $4 an acre, and the machinery and equipment charge is $6. About 3.5 pounds of twine are used per acre, or, roughly, 40 cents' worth. If the use of 40-bushel corn land (seven-ton silage land) is put in at $10.00 per acre, the total is $36.40 per acre under the same conditions as the production of corn husked from standing stalks costs $24.74. The silage at seven tons to the acre would cost about $5.20 per ton under the same conditions as No. 4 corn would cost 62 cents a bushel in the crib in December.

Production cost fallacies.—In any given year in a corn-growing community production costs are likely to range from 30 cents to $1.20 per bushel. Part of the range is due to accident, part to soil fertility, and part to good farm management. The man who is lucky enough to produce for 30 cents a bushel one year may find his costs 60 cents the year following. Moreover when the ability of the low-cost corn producers is taken into account it will be discovered if they are allowed wages on the basis of their intelligence and foresightedness that their production costs are not so low after all.

There are many ways of figuring cost of production. The price at which corn sells in the market for a period of years makes cost of production to some extent. For example if corn prices were only 30 cents a bushel for several years the result would be after a time a reduction in Corn Belt land values to $40 or $50 an acre, a reduction in wages paid to hired hands, and a reduction in the price paid for oats and hay to feed to horses. After such reductions it could then be said for a time that it cost only 30 cents a bushel to produce corn. However, after ten or fifteen years, it might be found that such a price would not pay farmers sufficiently to keep them from going to town. The production costs as given in the preceding pages totaling 62 cents a bushel in the crib in December are accurate enough when it is figured that farm land has lost 40 per cent of its value since 1920. And when it is remembered that farm-hand wages are only 60 per cent above pre-War, whereas city wages are 130 per cent above pre-War.

If we defined cost of production as the price necessary to give farmers the same share in the national income (a fair wage for farm labor and a fair return on non-deflated farm land) then the cost might be $1.20 per bushel. This is the viewpoint taken by the Farmers' Union and it is a fundamentally sound view in some ways if the farm problem is being approached from a long-time national viewpoint. But from the standpoint of the individual business farmer right here and now the thing to do is to take land values and farm wages as they actually exist and plan accordingly. The object is to produce cheaper than other farmers.

CHAPTER XXI

CORN ECONOMICS

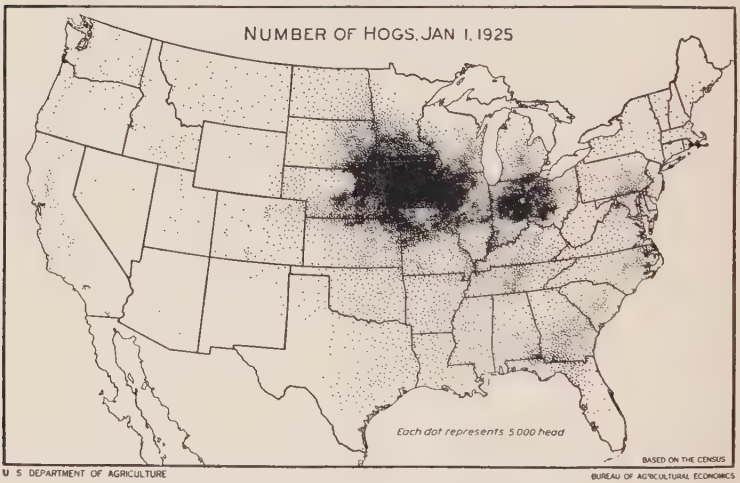
Corn-Hog Ratios

Corn and hogs influence each other profoundly. One year with another, hogs consume about 40 per cent of the corn crop of the United States, or as much as all of the other farm animals put together. Hogs are even more important as a market for corn than the foregoing indicates, for the reason that the horse, mule and dairy cow demand for corn is almost constant, whereas the hog consumption of corn often varies by as much as 15 per cent from one year to the next. Moreover, the 20 per cent of the corn crop which the farmers of the United States customarily feed to their horses and mules is used to keep the farm manufacturing plant running and is not a direct source of income. The corn which is sold in the form of hogs is far more significant than the corn which is used in any other way.

Close relationship. —Maps I and II illustrate the exceedingly close relationship between corn and hogs in the United States. It will be noticed that where the corn dots are thickest, so also are the hog dots. The outstanding exception is in central Illinois, where, with Chicago only 100 miles away, the comparative freight rates on corn and hogs are such as to make it more profitable on many of the rented farms to ship corn rather than hogs to Chicago. In the mountain and Pacific Coast states, the hog dots are thicker than the corn dots, the hogs being fattened on barley and milo. These western hogs are not sufficient to supply the home demand, and do not have com-

mercial significance in the same way as the hogs of the Corn Belt.

Chicago values as a basis for ratios.—With corn and hogs so dependent on each other, it is not surprising that there should be a close relationship between corn and hog prices. This relationship is known as the corn-hog ratio. As the average of the past fifty years, it has required on the Chicago market 11.5 bushels of No. 2 corn to equal in value 100 pounds of heavy

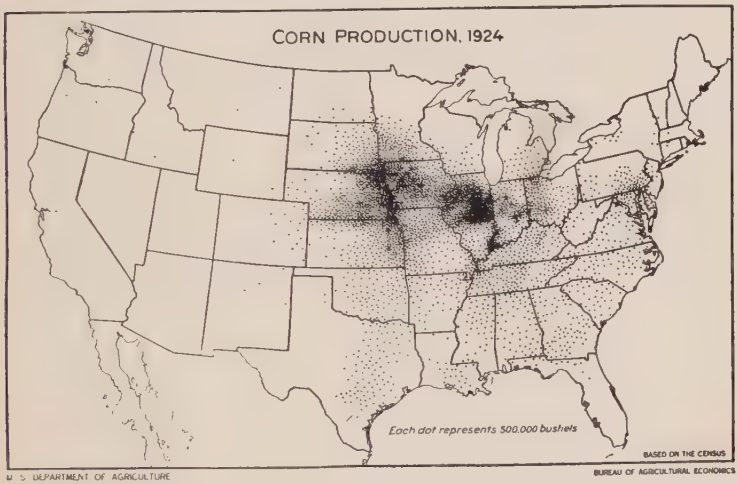

NUMBER OF HOGS, JAN 1, 1925
Each dot represents 5,000 head
BASED ON THE CENSUS
U S DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS

Courtesy of United States Department of Agriculture.

FIG. 94.—MAP I: Hog raising in the United States. Compare with corn map. Except in east-central Illinois hogs are thick where corn is plentiful. The California hogs are raised on barley and alfalfa.

hogs. In other words, with No. 2 corn at 50 cents a bushel at Chicago, the tendency has been for heavy hogs to sell for 11.5 times as much, or for $5.75 a hundredweight. Decade after decade, the ratio has averaged around 11 or 12 bushels on the Chicago market. Sometimes corn is so cheap and hogs are so high that the ratio may be 15 or 16 bushels for a year or so, but in such a case the result is the breeding of so many sows that there is an over-production of hogs and a shortage of corn (unless

the weather is unusually favorable), with the result that hogs become cheap and corn high and the ratio narrows suddenly to 10 bushels or even less. Usually, hogs sell for about two years below their long-time ratio with corn and then for about two years above it. Sometimes cholera, unusual business conditions, war, or exceptional weather modifies the swing of hog prices above and below their normal ratio, but even so the swings are only rarely shorter than twelve months or longer than thirty


CORN PRODUCTION, 1924
Each dot represents 500,000 bushels
BASED ON THE CENSUS
BUREAU OF AGRICULTURAL ECONOMICS
U. S. DEPARTMENT OF AGRICULTURE

Courtesy of United States Department of Agriculture.

FIG. 95.—MAP II: Corn Raising in the United States. Compare with the hog map and note tendency for corn and hogs to go together.

months. The chart illustrates the rhythmical nature of the corn-hog relationship. The zero line in this chart is the 11.5-bushel ratio corrected for the season of year (in December the ratio is about 11 bushels, whereas in the early spring it averages 12.4 under a situation where the average for the entire year is 11.5 bushels).

Ratio based on farm values.—If Corn Belt farm values are taken for both corn and hogs, instead of Chicago values, the

normal ratio is 13 bushels of farm corn to equal 100 pounds of farm hog, instead of 11.5 bushels. This difference is caused by the fact that farm corn is on the ear instead of shelled, and averages No. 3 grade instead of No. 2. Moreover, the freight rate on corn is a much higher percentage of its value than is the case with hogs, and this automatically tends to make the ratio higher on the farm than at Chicago. The Corn Belt farm ratio between corn and hogs has a normal seasonal range

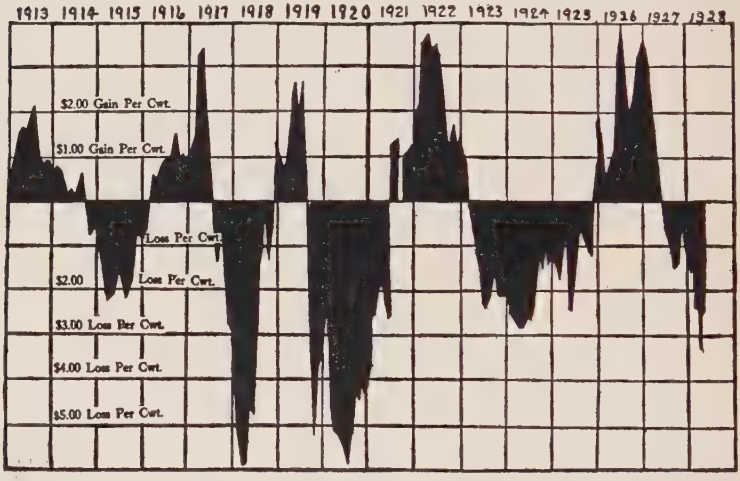


FIG. 96.—When the black areas are above the line it has been profitable to feed corn to hogs. Note that the typical swing is about two years each way.

from about 11 bushels during the late summer to 14 bushels in the early spring. In central Illinois, 100 miles south of Chicago, the corn-hog ratio, as a result of the freight rate situation, averages about 12.5 bushels over the same series of years that the ratio in northwestern Iowa is 13.5 bushels. The difference of one bushel in ratios explains why it is that northwestern Iowa farmers feed on the average 45 per cent of their corn to hogs, whereas central Illinois farmers feed only 25 to 30 per cent.

Over any period of time, the corn-hog ratio is a very delicate governor of the percentage of the corn crop which will be fed to hogs.

In the long run, the price which the consumers of the United States, England and Germany are willing to pay for pork and lard has more to do with determining corn prices than any other one thing. Corn farmers, even those who keep no hogs, should watch the hog market. If hogs are plentiful and low priced, it may mean a temporary scarcity of corn and high corn prices, but it also means that fewer sows will be bred for next year and that eventually a hog shortage will result, which means a corn surplus, unless unfavorable weather has caused a short corn crop at the same time as the short hog crop. Corn men should also be vitally interested in pork exports, for it is a matter of history that after several years of unusually heavy pork exports the tendency is toward an increase in corn prices. We normally export twice as much corn in the form of pork as in the form of grain. The corn-hog relationships are not as direct and immediate as many people think, but over any period of time it is astonishing how corn prices depend on hog prices, and vice versa.

Corn Prices

The dominating force making corn prices at Chicago is the size of the crop and especially the size of the crop in Illinois, Indiana and Ohio. At certain seasons of the year the Iowa corn crop and to a lesser extent the crop in the other Corn Belt states has some effect on Chicago prices. The crop outside of the Corn Belt has very little influence on Chicago prices. Statistical study suggests that the price-making forces vary at different seasons of the year.

Forces determining corn prices at Chicago in January.—In January the size of the Iowa corn crop seems to have more influence on Chicago corn prices than at any other time of year.

In fact one hundred million extra bushels of corn in Iowa in January seem to have fully as much, and perhaps even more importance, than a hundred million extra bushels in the eastern Corn Belt. The nature of the influence of the size of the Iowa corn crop and the size of the eastern Corn Belt corn crop is set forth in the following two tables.

TABLE XVI

No. 2 Corn Prices at Chicago in January

(Base price for January No. 2 Corn at Chicago 82 cents when the general price level is 50 per cent above 1913).

January Table I

(Influence of combined corn crop of Illinois, Indiana, and Ohio. To be used only in connection with Table II).

500,000,000 bushels	add	24 cents a bushel
600,000,000 bushels	add	10 cents a bushel
700,000,000 bushels	no change	
800,000,000 bushels	subtract	10 cents a bushel
900,000,000 bushels	subtract	20 cents a bushel

January Table II

Influence of Iowa Corn Crop
(To be used only in connection with Table I)

300,000,000 bushels	add	15 cents a bushel
350,000,000 bushels	add	7 cents a bushel
400,000,000 bushels	no change	
450,000,000 bushels	subtract	5 cents a bushel
500,000,000 bushels	subtract	10 cents a bushel

The use of these two tables is very simple. Assume for example that in a given year the combined corn crop of Illinois,

Indiana and Ohio is 600,000,000 bushels and that the Iowa corn crop is 350,000,000 bushels. If the base price at Chicago in January is taken as 82 cents the price in this particular year would be 82 cents plus 12 cents on account of the short eastern Corn Belt corn crop and 7 cents because of the short Iowa corn crop, or a suggested price of $1.01 at Chicago in January. Of course if the corn crop harvested fourteen months previously in the Corn Belt was large there will be a tendency for the price to be four or five cents a bushel lower than this, whereas, if the corn crop harvested fourteen months previously was small there will be a tendency for the price to be four or five cents higher than this.

An 82-cent base price for No. 2 corn at Chicago in January seems to be about what can be expected when the general price level of all commodities as reported by the Bureau of Labor Statistics, is about 50 per cent above 1913. Prices were approximately at this level in 1926, 1927 and 1928.

May corn price at Chicago.—Prices at Chicago in May are determined largely by the size of the corn crop harvested the preceding fall in Illinois, Indiana, Ohio and Iowa. By May, however, the size of the Iowa corn crop is not nearly so important as the size of the crop of the eastern Corn Belt. In fact a hundred million extra bushels of corn in the eastern Corn Belt has more than twice as much influence on Chicago May corn prices as a hundred million extra bushels in Iowa. It is rather strange that the size of the corn crop outside of these four Corn Belt States seems ordinarily to have very little influence on Chicago May prices.

A new factor comes into action in May which apparently has very little influence in the early winter. This is oat prices at Chicago. Oat prices at Chicago in October seem to have only slight value in predicting corn prices the following January, but very real value in predicting corn price the following May.

The following three tables are quite useful in suggesting the way the three forces generally work in determining the May corn price at Chicago.

TABLE XVII

MAY NO. 2 CORN PRICES AT CHICAGO

(Base price for May corn is 90 cents a bushel when the general price level is 50 per cent above 1913).

MAY TABLE I

Influence of Oat Prices of the Preceding October at Chicago.

(To be used only in connection with Tables II and III)

40 cents	subtract 8 cents
42 cents	subtract 6 cents
46 cents	subtract 3 cents
50 cents	no change
54 cents	add 3 cents
58 cents	add 6 cents
60 cents	add 8 cents

MAY TABLE II

Influence of Combined Corn Crop of Illinois, Indiana and Ohio Crop of Preceding Year

(To be used only in connection with Tables I and III)

500,000,000 bushels	add	18 cents
600,000,000 bushels	add	8 cents
700,000,000 bushels	no change	
800,000,000 bushels	subtract	7 cents
900,000,000 bushels	subtract	14 cents

MAY TABLE III

Influence of Iowa Corn Crop of Preceding Year

(To be used only in connection with Tables I and II)

300,000,000 bushels	add	8 cents a bushel
350,000,000 bushels	add	4 cents a bushel
400,000,000 bushels	no change	
450,000,000 bushels	subtract	2 cents a bushel
500,000,000 bushels	subtract	4 cents a bushel

It will be noted that the base price for May corn is taken at 90 cents a bushel as compared with 82 cents a bushel for January corn. In the case of May corn as with the January corn it is assumed that this base price is about right when the general price level is about 50 per cent above 1913 as was the case in

1926, 1927, and 1928. If the general price level should decline it would also be necessary to lower this base price.

September corn prices at Chicago.—In early September the biggest single influence bearing on corn prices is the outlook for the new crop which is just maturing, but which has not yet been harvested. The old crop of the year before still has influence, but only the crop in the Eastern Corn Belt; the Iowa corn crop seems to be out of the picture entirely at this time of year.

A price-making force which seems to have considerable influence in early September, but which has very little influence in January is the visible supply of corn at the terminal markets. When there are more than twenty million bushels of corn in storage at the terminal markets in the early summer the result is a weakening effect on corn prices during August and September. In fact it seems that one million extra bushels of corn at the terminal markets in the summer time tends to damage corn prices at Chicago in September as much as twenty million extra bushels on Corn Belt farms.

The following September tables are comparable with the May and January tables which have just been presented:

TABLE XVIII

No. 2 Corn Prices at Chicago in Early September

(Base price is 95 cents when general price level is 50 per cent above 1913).

September Table I

Influence of Chicago Oat Prices, Preceding June

(To be used only in connection with Tables II, III, and IV)

46 cents	subtract	6 cents
50 cents	subtract	4 cents
54 cents	subtract	1 cent
56 cents	no change	
58 cents	add	1 cent
60 cents	add	2 cents
62 cents	add	4 cents
64 cents	add	5 cents
66 cents	add	6 cents
68 cents	add	7 cents

SEPTEMBER TABLE II

Influence of Combined Corn Crops of Illinois, Indiana, and Ohio, in Preceding Year

(To be used only in connection with Tables I, III, and IV)

500,000,000 bushels	add	9 cents
600,000,000 bushels	add	3 cents
700,000,000 bushels	no change	
800,000,000 bushels	subtract	2 cents
900,000,000 bushels	subtract	4 cents

SEPTEMBER TABLE III

Influence of Visible Supply of Corn on June 1 Preceding

(To be used only in connection with Tables I, II, and IV)

5,000,000 bushels	add	4 cents
10,000,000 bushels	add	2 cents
15,000,000 bushels	no change	
20,000,000 bushels	subtract	2 cents
25,000,000 bushels	subtract	4 cents
30,000,000 bushels	subtract	6 cents
35,000,000 bushels	subtract	8 cents

SEPTEMBER TABLE IV

Influence of Government Predicted Corn Yield as of September 1, in Illinois, Indiana, Ohio, and Missouri in millions of bushels

(To be used only in connection with Tables I, II, and III)

550,000,000 bushels	add	20 cents
600,000,000 bushels	add	16 cents
650,000,000 bushels	add	12 cents
700,000,000 bushels	add	8 cents
750,000,000 bushels	add	4 cents
800,000,000 bushels	add	2 cents
850,000,000 bushels	no change	
900,000,000 bushels	subtract	3 cents
950,000,000 bushels	subtract	6 cents
1,000,000,000 bushels	subtract	9 cents

September Table IV deals with the Government estimate of the growing crop as of September 1. This is usually published in the Chicago daily papers about September 9. However,

anyone living in the Corn Belt and especially anyone who has access to rainfall and temperature records as they develop day by day during July and August can predict the yield of corn for these four states with a fair degree of accuracy by August 15. The prospective yield in Illinois and Indiana seems to be especially important in determining Chicago corn prices early in September.

Other influences on prices.—Business conditions usually have a little influence on corn prices although the effect is usually very small except in the case of an extraordinary deflation of currency such as took place in 1921. As a general rule it can be said that business conditions do not have an effect of more than two or three cents a bushel on corn prices either up or down.

Hogs have an influence on prices when they are exceedingly numerous or exceedingly scarce. In 1909 and 1910, for instance, when the number of hogs to eat corn was much less than usual, the result was a decided weakening in corn price. Occasionally there are so many hogs being fed that the price of corn has been helped by four or five cents a bushel. In any ordinary year, however, neither the number of the hogs in the country nor the price of hogs has any effect on corn prices. In the long run, corn prices and hog prices are perfectly responsive as was demonstrated in the early part of this chapter, but at any particular moment there seems to be little or no relationship.

Corn prices and wheat prices.—There is no close, intimate relationship between corn prices and wheat prices. Wheat prices are made by the world market and are often quite independent of conditions in the United States. Corn prices, on the other hand, are very sensitive to the domestic situation. During the winter months on the Chicago market, corn prices per bushel represent a value from 40 to 70 per cent as great as wheat values. During the late summer, in years of a large winter wheat crop and a small corn crop, it occasionally happens that corn will sell for 85 per cent as much as wheat.

Since the Civil War, corn has gradually been creeping a little closer to wheat in value, because of the fact that the wheat

lands are not yet fully occupied, whereas very little new corn land has been brought into use at any time in the past twenty years. It seems very doubtful, however, if corn can ever become, over a period of years, more than 85 per cent as valuable per bushel as wheat. Wheat weighs 60 pounds per bushel, whereas corn weighs 56 pounds; wheat normally runs considerably lower in moisture, and contains a type of gluten which makes it the ideal bread grain. Corn prices may continue to gain slightly on wheat prices, but from now on it is probable that this gain will not be very rapid. After the wheat lands of the world become fully occupied and wheat begins to rise in price faster than the general price level, it is to be expected that corn will advance at about the same rate as wheat, although on the average it will probably always sell for at least 20 per cent less per bushel than wheat on the Chicago market. Wheat prices presumably set the upper limit beyond which corn prices cannot go for any length of time.

Weather and corn prices.—Since the size of the crop (discussed in the first paragraph of this chapter) has far more to do with corn prices than all the other factors put together, it is especially important to study the weather in its relation to the size of the crop. This is gone into in great detail in Chapter XXII. Suffice it to say here that the all-important weather from the standpoint of corn prices is the rainfall and temperature from July 1 to August 20. During this period, it requires an average of about 1 inch of rainfall every ten days to hold new crop futures (December and May) corn prices steady. More than 1 inch of rainfall in ten days tends to lower corn prices, 1.4 inches or more tending to cause a drop of 2 or 3 cents a bushel. Less than half an inch of rainfall in ten days tends to cause an advance of 3 or 4 cents a bushel. If there has been an average of less than a tenth of an inch of rain during the ten-day period, and if the mean temperature has averaged above 80° the corn price may run up 6 to 8 cents a bushel. To determine the average rainfall, it is necessary to have reports from at least twenty representative stations in each of such states as

Iowa, Illinois, Indiana, Ohio, Missouri, Nebraska and Kansas. The Illinois, Indiana and Missouri stations are most important. The daily corn and wheat region bulletin, which may be obtained from the Chicago Weather Bureau, gives such information. Occasionally, unusually cold or wet weather in May and June will advance the speculative new crop futures very materially, as was the case in 1927. As a rule, June weather has very little effect on new crop corn futures, but if the weather has been exceptionally dry during the spring, a widespread June rain may break December corn futures by 5 cents or even more per bushel, as was the case the third week in June of 1925.

Once in a long while a killing frost in September or early October may cause December corn futures to rise, but as a rule the possibility of frost damage has been discounted in advance because it has been known for some time that the crop was backward and likely to be damaged by frost. Perhaps once in five or six years early fall frost may have a little influence on price of December corn futures.

In the typical season, the outstanding weather influencing the size of the new corn crop and the price of new crop futures is the rainfall and temperature in July and early August.

Influence of shrinkage and time of year.—Illinois and Iowa experiments indicate that, on the average, corn picked early in November will shrink about 3 per cent during November, 2 per cent during December, 1 per cent in January, 1 per cent in February, 1 per cent in March, 3 per cent in April, 3 per cent in May, 2 per cent in June, and 1 per cent in July, normally a total of about 17 per cent shrinkage from cribbing time in November until the middle of the following summer. Of course, there is considerable variation in the years. If the fall is dry and the corn is unusually well matured, the shrinkage may amount to only 9 or 10 per cent, whereas in wet, cold falls the shrinkage may be as high as 25 per cent. The monthly figures represent normal conditions. In some years, however, the really heavy shrinkage will start in late March, in other years in April, and occasionally not until June. Ordinarily, though,

late April and May is the time of the heaviest shrinkage in corn, much depending, however, on the temperature and the humidity.

On the basis of shrinkage alone, it would take, to equal a price of 50 cents a bushel for corn in November, a price of 55 cents in April and 58 cents in July. When interest is added at 6 per cent, and allowance is made for the overhead investment in the crib, and for a small amount of rattage, it will be found that in the ordinary year it will take, to equal a price of 50 cents a bushel for corn in November, about 52 cents in December, 53 in January, 54 in February, 55 in March, 57 in April, 59 in May, 60 in June, 62 in July, and 62.5 cents in August. The actual pre-war normal price for corn on Iowa farms was 49 cents a bushel in late November and December, 50 cents in January, 51 in February, 53 in March, 56 in April, 59 in May, 61 in June, 63 in July, 63 in August, and 61 cents in September. This would indicate that before the War, it was normally a good plan to sell corn in late November, if possible, rather than to sell in December, January, February or March. Rather than to sell in these months, it seemed usually to be a good plan to hold for a June, July or August market.

Corn Prices and General Price Situation

Corn prices as affected by the general price level.—Whenever the general price level rises as a result of the abundant currency which follows upon an increased gold supply, improved banking methods, or war, it is inevitable that corn prices also should rise. From 1896 to 1913, the general tendency of corn prices was upward, because prices of all kinds were going up as a result of the sudden increase in gold output accompanied by improved banking methods. From 1915 to 1920, the War demand, accompanied by currency inflation, sent prices of all kinds up, and corn moved in sympathy.

From 1896 to 1913, food prices of most kinds increased somewhat more rapidly than prices generally, because the great overproduction of food resulting from the opening of the Mississippi

valley was finally absorbed. Corn prices advanced more rapidly than most other food prices, because the corn land of the world was quite fully exploited before the wheat, oat and rye land.

If we express the relation between farm corn prices and the general United States price level as 100, in the decade 1906–1915, then the relation during the twenty years extending from 1866 to 1885 was 79, whereas the relationship during the decade of 1886–1895 was 88 and during the decade of 1896–1905 the relationship was 87.

Using the same method, we find the corn crops of 1920, 1921 and 1922 selling for an average of only 61, as compared with 100 from 1906 to 1915. This very low relationship was caused partly by the inability of Europe to pay normal prices for our surplus corn and pork products and partly by the ability of organized labor and organized business to hold up manufactured products and freight rates to a high level. Corn prices will doubtless reach again their 1906–1915 ratio to the general price level by the decade of 1931–1940. The decade of 1921–1930 is one of readjustment and uncertainty. The crops of 1925, 1926, and 1927 sold on the average for about 85 per cent of what they should have sold for in order to have their 1906–1915 relationship to the general prive level of all commodities.

Corn-prices and wages of city labor.—From 1841 to 1860, a bushel of corn on the Chicago market sold for the value of four hours of city labor. From 1873 to 1902, a bushel sold for the value of 2.3 hours. From 1903 to 1912, a bushel sold for the value of 2.4 hours of labor. Corn in 1921 and 1922 sold on the basis of 1.2 hours of labor per bushel; in 1924, 1.9 hours; and in 1925 to 1927, 1.6 hours.

During the four years before the War (1911–1914), it required about 1170 bushels of Chicago corn to equal the yearly wages of the railroad man; in 1921 and 1922, 2700; and 1900 bushels in 1925 to 1927.

Theoretically, it is to be assumed that in the long run the volume of city labor will increase more rapidly than the output

of corn, and that therefore the tendency will be for the yearly wages of city labor to buy fewer and fewer bushels of corn. Labor-saving inventions both on the farm and in the cities tend to postpone this eventual outcome. Temporarily also, labor organizations can hold wages above the ratio with corn prices justified by the fundamental economic situation. This results oftentimes, however, in larger numbers of corn farmers looking

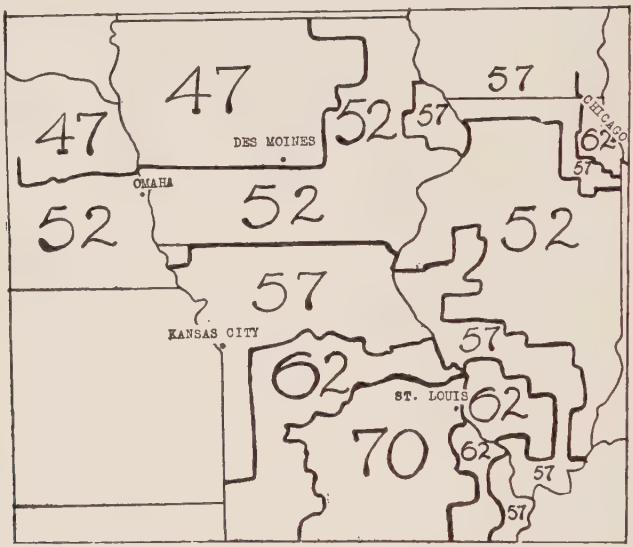


Fig. 97.—Geography of corn prices, 1910–1914.

for work in the cities. It is to be expected, therefore, that the situation of the decade 1921–1930 will not continue indefinitely, but that corn prices will after a time come to have as favorable a ratio with the wages of labor as in 1911–1914.

Geography of corn prices.—Before the War, the United States Department of Agriculture made a geographical study of corn prices for the five-year period, 1910–1914. The outstanding feature of this investigation was that the center of cheap corn was in northwestern Iowa, northeastern Nebraska,

southeastern South Dakota and southwestern Minnesota. When No. 2 corn was 61 cents a bushel on the Chicago market during December, it was customary for corn on farms in northwestern Iowa to sell about 14 cents a bushel cheaper, or around 47 cents a bushel. Eastward and southeastward of the cheap corn section in northwestern Iowa, corn prices before the War

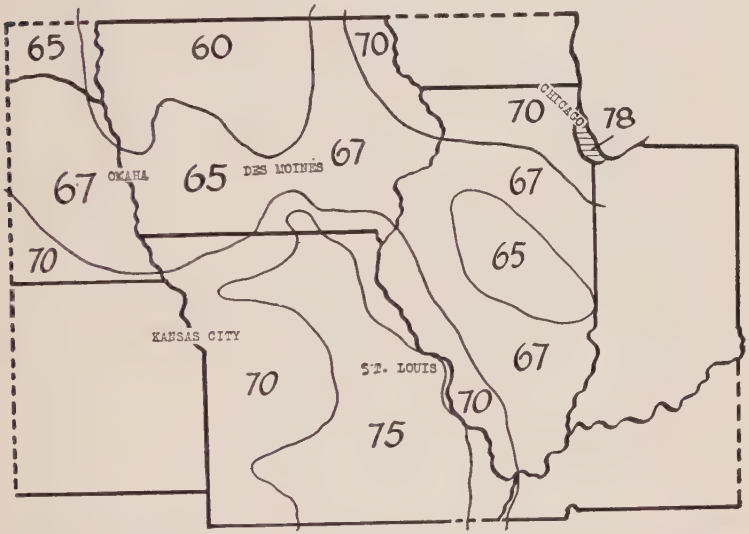


FIG. 98.—Geography of corn prices 1922–26. Note that northwestern Iowa is still the center of the cheaper corn prices.

ordinarily tended upward at the rate of about 3 cents every hundred miles.

A study based on the five-year period 1922–1926 indicates that northwestern Iowa, northeastern Nebraska, southeastern South Dakota and southwestern Minnesota still comprise the cheap corn section. The really great difference between the two maps is caused by the increase in freight rates. During 1920 and 1921, the cost of shipping a bushel of corn from northwestern Iowa to Chicago was 7 or 8 cents more than before

the War, and in 1922, after the reduction was made, the cost was still about 4 cents a bushel more than before the War.

From the standpoint of producing surplus corn for the Chicago market, the only region which compares with northwestern Iowa is central Illinois. The corn price in this section would be just as low as in northwestern Iowa except for the fact that it is two hundred miles closer to Chicago. Before the War, this gave it an advantage of 5 cents a bushel. Since the War, as a result of the increase in freight rates, the advantage has amounted to at least 7 or 8 cents a bushel.

In southern Missouri and southern Illinois, with the exception of a very small area along the river in extreme southeastern Missouri, there is no surplus corn whatever to ship to market. Home-grown livestock furnishes the market, and the corn price customarily is almost as high as the Chicago price. In fact, there are sections of the Ozarks where corn almost invariably sells higher than at Chicago. There are parts even of northern Missouri where corn is often shipped in. During 1921 and 1922 for instance, there were sections of northern Missouri where the corn price averaged around 65 cents at a time when only 200 miles away, in central Iowa, the price was 42 cents. This situation encouraged a considerable movement of Iowa corn southward instead of to Chicago.

In studying the two maps, keep in mind that the prices are based on December 1 farm values. During the summer-time when there is less moisture in the corn, and when a corn shortage develops in many localities, farm corn prices much more nearly approach the Chicago corn prices.

For the five years, 1921-1925, average December 1 corn prices for representative states in different sections of the country were: South Dakota, 53 cents; Iowa, 59 cents; Illinois, 63 cents; Ohio, 68 cents; Pennsylvania, 83 cents; New York, 93 cents; Massachusetts, $1.05; Georgia, 92 cents; Texas, 91 cents; Colorado, 64 cents; Idaho, 79 cents, and California, $1.08. The corn price rises rapidly in every direction from

the center of cheapest corn, where Iowa, Nebraska, South Dakota and Minnesota come together.

Corn Value

The ultimate value of corn is as a source of fuel or power. A bushel of ear corn contains about the same number of British Thermal Units as 50 to 60 pounds of ordinary soft coal. When soft coal is above $15 a ton and corn is less than 30 cents a bushel, corn may derive a part of its value from its heating content. This situation is reached only in communities remote from coal mines and terminal markets in years when the general economic situation is demoralized and the corn crop is very large.

When crude oil becomes so scarce that gasoline sells wholesale above 50 cents a gallon, it is possible that alcohol made from corn at 75 cents a bushel can compete with the gasoline as a source of power for automobiles and trucks.

Under ordinary conditions, corn derives its value largely from its ability to furnish fat-forming material to hogs more cheaply than any other grain. By means of the corn-hog combination, it is possible to produce palatable meat with a less expenditure of land and human labor than in any other way. Corn is the most efficient plant of the temperate zones in fixing the energy of the sun's rays, and the hog is the most efficient meat animal for converting that sun energy of corn into a palatable form for human consumption. Corn also derives a part of its value from its ability to furnish the 22,000,000 farm work horses and mules of the United States the cheapest energy which can be obtained in any grain.

Heretofore, corn has derived only a small part of its value from its use in factories and mills. Its use in this way is steadily growing, however, and eventually the corn food products as manufactured will have as much to do with corn values as the ham, bacon and lard which are made by the hog out of corn. Commercial corn products are discussed in Chapter XXIII.

Government Corn Crop Reports

The most important government corn crop reports are issued during the growing season. The one which is ordinarily issued in the daily press on July 8, or 9 gives a judgment of the crop reporters of the United States as to the condition of the corn crop on July 1, previous. In like manner in early August there is issued a report as of August 1, and in early September a report as of September 1. These government condition figures are given in terms of a percentage, which usually ranges somewhere between 60 and 95.

Thousands of men scattered all over the Corn Belt serve as crop reporters for the United States Department of Agriculture and on July 1 of every year they send in their reports. They do not estimate how much the corn will yield in bushels per acre but they send in a figure representing what percentage they think the corn will yield of normal. From the way it works out in practice, the crop reporters appear to look on the word normal as meaning a crop which is somewhat above average but not perfect. In Iowa, for example, the average corn crop for the past ten years has been about 40 bushels per acre. In the eyes of the crop reporters the normal corn crop is about 10 per cent greater than this or 44 or 45 bushels per acre. Under the United States Department of Agriculture statistical system a figure which is normal or par on July 1 may not be normal or par on August 1. For instance, in 1927 the National Department of Agriculture used as a normal or par figure for Kansas 23 bushels per acre for July 1, 26.5 bushels per acre for August 1, and 35.7 bushels per acre for September 1. The government theory is that 100 equals normal or par. If the crop reporters of Kansas estimate on July 1 that the condition is 70 per cent then the outlook in terms of bushels per acre in Kansas is 70 per cent of 23 bushels or 16.1 bushels. In like manner if the condition figure reported on August 1 for Kansas is 50 per cent, then the prospective yield in bushels per acre is 50 per cent of 26.5 or 13.25 bushels per acre.

United States Department of Agriculture pars or normals as they were used in 1927 are given in the following table:

	July	August	September	October
Indiana	45.0	44.5	44.0	44.0
Illinois	44.0	43.8	43.5	45.0
Iowa	44.5	45.0	46.5	46.0
Missouri	35.0	35.5	36.5	36.0
South Dakota	30.5	32.0	35.5	35.0
Nebraska	29.0	31.5	36.0	37.0
Kansas	23.0	26.5	35.7	36.0
Ohio	47.8	47.5	47.0	47.5

The condition figures as reported from the Corn Belt states for 1927 were:

1927 Reported Condition Figures in Percentage of Normal or Par

	July	August	September	October
Indiana	56	58	56	62
Illinois	57	57	53	60
Iowa	72	73	67	75
Missouri	64	70	72	77
South Dakota	72	76	72	78
Nebraska	80	81	85	85
Kansas	76	83	91	90
Ohio	63	65	62	68

By using these two tables together it is possible to get the government predicted yield figure per acre. For example on July 1 of 1927, the government predicted yield figure per acre for Indiana was 56 per cent of 45 bushels or 25.2 bushels. As an average of a long period of years the condition figure in the central Corn Belt states is ordinarily around 80. The actual

figures as reported by the government during the summer and early fall months for the past thirty-seven years are given in the last chapter of this book. The speculators on the Chicago Board of Trade watch with great care the condition figures as reported by the Department of Agriculture during the summer and early fall months. Farmers have not watched the condition figures so carefully because they have not known how to interpret them. They have not known whether a condition of 85 was relatively good or relatively bad. To develop judgment on this matter it is worth while to study with care the table given in the last chapter of this book.

CHAPTER XXII

CORN AS AFFECTED BY TEMPERATURE AND RAINFALL

Corn requires abundant moisture and a moderately high temperature if it is to make its best growth. Laboratory experiments indicate that when plenty of moisture is available, a temperature of about 90 degrees is most favorable both for germination and growth. Growth stops altogether at temperatures of below 40 degrees or above 118 degrees.

Temperature for germination.—In most corn-growing sections, the temperature during the week following planting is around 60 to 65 degrees, and under such a temperature corn usually appears above ground in eight or ten days. When the ground is cold and the temperature averages 50 to 55 degrees, it usually takes eighteen or twenty days for the corn to come up. When the temperature is less than 55 degrees, the slowly sprouting corn kernels are very susceptible to root rot infections; whereas, when the temperature is above 60 degrees the kernels are much more resistant. If the soil is warm and moist and the corn is planted shallow, a temperature of 70 degrees will bring it above ground in five or six days. In the central part of the Corn Belt, yield and temperature records indicate that a mean temperature of 55 degrees or less during May tends to reduce the yield by about 15 per cent. A temperature of 56 to 58 degrees will not ordinarily cut the yield by more than 3 or 4 per cent, unless accompanied by heavy rains and prolonged cloudy weather.

Temperature and rainfall during June.—From the time the corn comes up until it reaches a height of 3 feet, it is necessary under practical farm conditions to give three or four

cultivations, in order to kill the weeds. This can be accomplished most effectively when June is rather hot and dry. A mean temperature of 70 to 72 degrees in June, with 2 to 4 inches of rain, seems to be ideal. A mean temperature of more than 75 degrees for the month of June is so often accompanied by exceedingly dry weather, not only in June but also in July, that it is a matter of history that years of exceedingly hot Junes are usually years of below-average corn crops.

July weather and corn yield.—In Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska and southern Iowa, the rainfall and temperature during the ten days before and the twenty days following tasseling time have more to do with corn yield than the weather at any other period. Ideally, there should be 4 or 5 inches of rainfall during this thirty-day period, and the mean temperature should average from 72 to 74 degrees. Corn appreciates mean temperatures as high as 85 degrees, but as a practical proposition, mean temperatures above 75 degrees nearly always lower the yield for the reason that such temperatures cause the corn plants to transpire water more rapidly than they can take it up from the ground. This might not be true under irrigation, but in the Corn Belt mean temperatures above 75 degrees are usually accompanied by drouth. It is also true that a drouth which would cause very little bother at 70 degrees may be a serious matter at 80 degrees, for it has been found at the Nebraska station that a full-grown corn plant will transpire daily about 4 pounds of water at a mean temperature of 70 degrees, whereas at 80 degrees it will transpire about seven pounds.

During this thirty-day period, on land capable of producing 40 bushels per acre under favorable conditions, each degree that the mean temperature averages above 74 degrees cuts the corn yield by about 1.2 bushels per acre, and each inch the rainfall is below 4 inches cuts the yield by 2 bushels. For instance, with land yielding 40 bushels per acre under the best conditions, if the corn starts to tassel on July 18 and the

temperature from July 8 to August 7 averages 78 degrees and the rainfall totals 2 inches, the indicated yield would be 40 bushels minus 4.8 bushels because of high temperature and 4 bushels because of drouth, or 31.2 bushels.

A general 1-inch rain during late July often increases the prospective crop of the Corn Belt states by 2 or 3 bushels

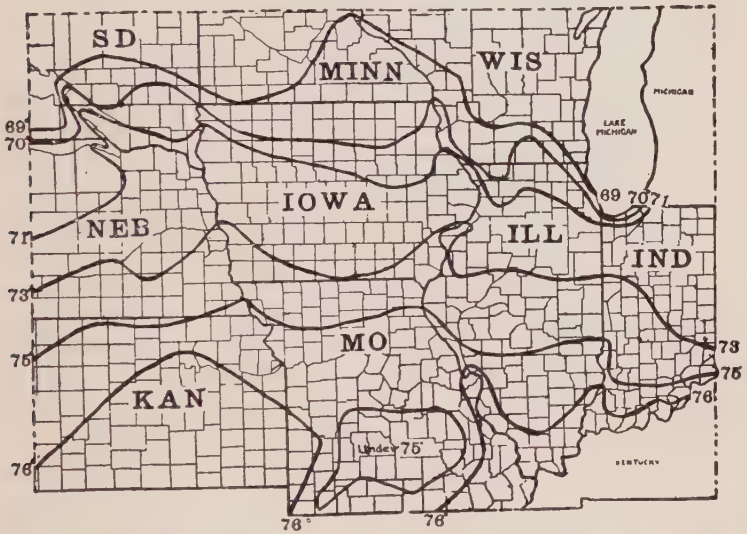


FIG. 99.—Average temperature isotherms during June, July, and August in the Corn Belt. The most productive corn land is north of the 75-degree line and south of the 69-degree line. Only in southwestern Minnesota is there really good corn land somewhat north of the 69-degree line. The breeding of high-yielding early varieties may possibly push the northern limit of the Corn Belt beyond the 69-degree line.

per acre, or by a total of over 100,000,000 bushels. Some people have, therefore, spoken of such a rain as worth millions of dollars to the farmers. As a matter of fact, December future corn prices as set by the Chicago Board of Trade during July and early August reflect these rains in such a way as to leave

the total prospective value of the new crop changed but little. The rain which increases the prospective corn crop of the Corn Belt by 100,000,000 bushels, or by 7 per cent, will also lower December corn future prices by 6 to 12 per cent. The July and early August rains which add 100,000,000 bushels to the

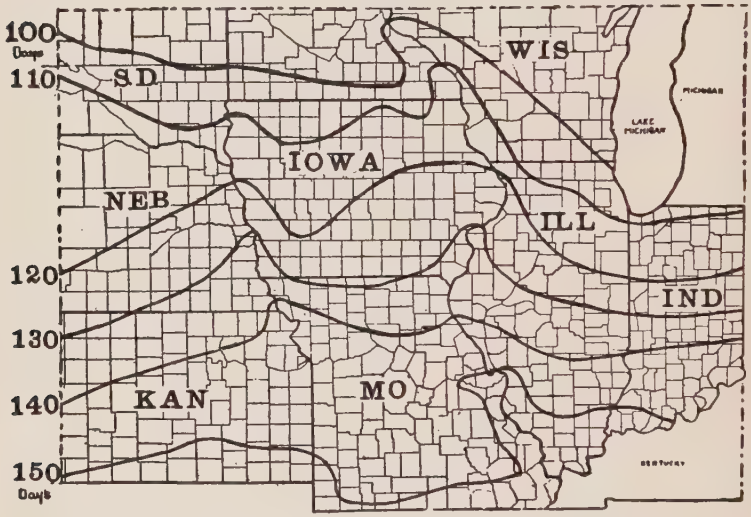


FIG. 100.—Number of days from time temperature normally rises above 61 degrees in spring until it goes below 65 degrees in the fall. This map indicates fairly accurately where the early maturing strains are required. In northeastern Illinois much earlier varieties are required than in the same latitude in Iowa. In northeastern Iowa earlier varieties of corn are required than in northwestern Iowa even though the former has a longer season. The explanation lies in the soil type and the slowness with which it warms up in the spring.

coming crop of the Corn Belt usually result in the new corn being priced 4 or 5 cents a bushel cheaper, or enough to make the total value actually somewhat less than if the rain had not come. It is the corn product manufacturers, exporters, and stockmen who buy more corn than they raise, who benefit by the July and August rains which increase the corn crop. And,

of course, it is always true that those corn sections which receive heavy July rains when the Corn Belt generally is hot and dry benefit enormously at the expense of their less fortunate neighbors.

December future corn prices and July weather.—Generally speaking, the Chicago December future corn price, as quoted

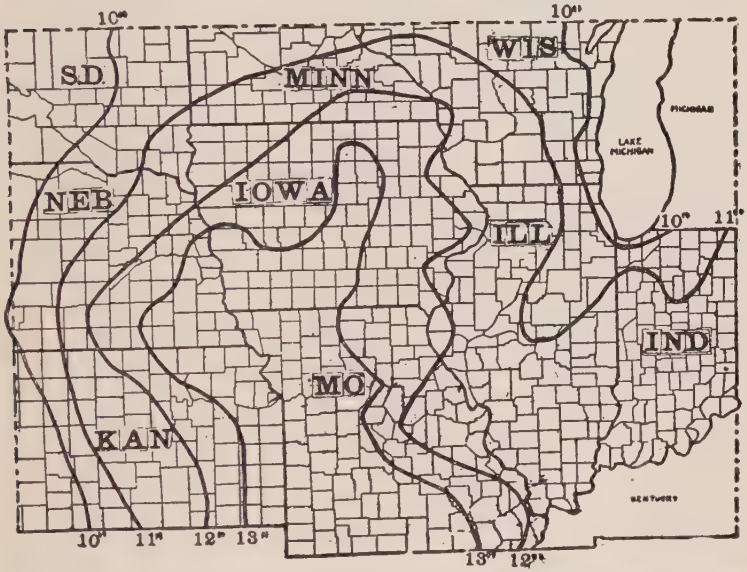


FIG. 101.—Average inches of rainfall in three summer months of June, July, and August.

day by day during July and August in the daily papers, is the best measure for the average farmer of how the new corn crop of the entire Corn Belt is being treated by the weather. If on July 30 the December future price is 6 cents a bushel higher than on July 20, it is an indication that there has been practically no rain anywhere in the Corn Belt during the past ten days. If the price during this period has dropped by 2 cents a bushel, it is almost certain that there have been abundant,

well-distributed rains over the greater part of the Corn Belt. Sometimes December corn futures during July and August are affected to some extent by business conditions and by wheat prices, but as a rule they move up and down in sympathy with Corn Belt weather and very little else.

Northern Iowa and southern Minnesota differ from the central part of the Corn Belt in that they are more likely to be damaged by cold and wet during May and June than by heat and drouth during July. It is only in years of exceptional drouth, like 1894 or 1901, that the northern part of the Corn Belt is likely to suffer much from hot July weather. Even in such years, the corn of the northern Corn Belt is usually not so very far below normal, whereas there is a great shortage in the central and southern parts of the Corn Belt. The net result, as a rule, of dry, hot July weather, so far as northern corn farmers are concerned, is prosperity at the expense of the corn farmers farther south. On the other hand, cold, wet summers like 1915 and 1917 hurt the corn yields in the north and boost those south of central Iowa.

From a commercial standpoint, drouth and heat during July and early August have much more effect on the corn market than cold and wet at any time of the year.

August weather.—Over most of the Corn Belt, heat and drouth during the first half of August are almost as likely to hurt the corn crop as heat and drouth in July. Missouri, Nebraska and Kansas corn is expecially susceptible to heat damage during the first half of August. North of central Iowa, however, the corn yield is more likely to be damaged by cold weather in August than by hot weather. August weather averaging below 69 degrees seems to damage the corn crop in northern Iowa and southern Minnesota, especially in years when the May, June and July weather has also been a little cooler than normal. The ideal August weather is a temperature of 72 to 73 degrees and a rainfall of 4 or 5 inches.

After August 20, the weather usually has very little significance. The corn plant at this time is manufacturing and

storing sugar and starch much more rapidly than earlier in the season. Nevertheless, after thirty days have lapsed following tasseling, moderately dry weather seems to do no damage. Rainfall is important while the young corn kernels are just forming but is not so necessary when the corn plant is most actively at work storing food in these kernels during late August.

Frost.—Frost has far less effect on the corn crop than most people think. In a season which has been usually cool throughout, like 1915 or 1917, a September frost may cause much soft corn north of southern Iowa. Occasionally, as was the case in 1920 and 1927, unusually warm September weather enables the corn crop to avoid the frost damage which seemed almost inevitable. It is only rarely that frost causes any widespread damage to corn. As a rule, most corn is sufficiently matured to withstand frost damage two or three weeks before killing frost actually comes. Frost damage is rarely reflected in the price of corn on the terminal markets in the same way as heat and drouth damage.

Heat and rapidity of growth.—While mean temperatures above 74 degrees during the twenty days following tasseling time seem to harm the corn crop, it is also true that previous to tasseling time the rapidity with which the corn grows depends largely on the temperatue. During June and early July, corn grows twice as fast on those days when the mean temperature is 78 degrees as it will when the mean temperature is only 62 degrees. A 75-degree mean results in about 25 per cent faster growth than 70 degrees. A number of years ago, the Pennsylvania station found that during the three weeks preceding tasseling time there was a tendency for corn to grow in twenty-four hours at the following rates at varying mean temperatures:

65 degrees	3.2 inches
70 degrees	4.1 inches
72 degrees	4.5 inches
75 degrees	5.1 inches
78 degrees	5.4 inches

The average temperature during the fifty or sixty days following planting time is the chief influence determining just when a given variety of corn will tassel. With the ordinary 115-day strain of such varieties as Reid Yellow Dent, the temperatures during the sixty days following planting result in varying lengths of time till tasseling:

68 degrees.....71 days from planting to tasseling
70 degrees.....67 days from planting to tasseling
73 degrees.....59 days from planting to tasseling

With a so-called ninety-day strain, the corresponding table, based on temperatures during the forty-five days following planting time, is:

67 degrees.....57 days from planting to tasseling
69 degrees.....50 days from planting to tasseling
71 degrees.....45 days from planting to tasseling

All three of the tables given here apply most accurately to average Corn Belt soil. On soil of unusual fertility the rate of growth will be somewhat more rapid.

The number of days from tasseling to ripening does not vary with the heat in the same clear-cut fashion as the number of days from planting to tasseling. With most varieties of corn it takes from fifty to sixty days from tasseling to maturity with ordinary temperatures.

Extremely high temperatures (above 95 degrees during the heat of the day) may kill the pollen within an hour or two after it is shed and thus cause poor pollination if the high temperatures are continued day after day at the time the pollen is flying. The storing of food in the corn kernel during late July and August is an altogether different process than the rapid growing of the corn plant during late June and early July. Hot weather does not have as much to do with hastening ripening as it does with causing rapid growth before tasseling.

Cold nights.—It is a common belief that corn will not grow satisfactorily in regions where the nights are cool though the

days are warm. Usually, the true explanation why corn is not grown in such sections is something else. In South Africa, where corn growing has expanded at a phenomenal rate since 1900, the minimum temperature at night during the tasseling season averages only about 60 degrees, and in some sections it is as low as 55 degrees. Cool nights reduce the rapidity of growth previous to tasseling, but if the season is long there is no definite proof that cool nights (55 to 60 degrees at the low point of the night) reduce the yield.

Summary.—The ideal corn season in the central part of the Corn Belt is about as follows:

May—65-degree mean temperature (warmer than average), 3.5 inches of rain.

June—71-degree mean temperature, 3.5 inches of rain.

July—73-degree mean temperature (cooler than average), 4.5 inches of rain.

August—73-degree mean temperature, 4.5 inches of rain.

September—Warmer and drier than average, especially if the earlier months have been cool.

October—Same as September. It is usually in cold, backward seasons that September and October have any great significance. Dry weather in October helps the quality of the corn and enables it to grade sooner than would otherwise be the case.

No temperatures above 96 degrees in the heat of the day at tasseling time, ground thoroughly saturated with moisture during the twenty days following tasseling.

CHAPTER XXIII

COMMERCIAL PRODUCTS OF CORN

About 220,000,000 bushels, or 8 per cent of the corn crop of the United States, is manufactured annually. Roughly, 100,000,000 bushels, or 4 per cent, are ground in the corn meal mills, and 80,000,000 bushels, or 3 per cent, are handled by the starch factories. About 40,000,000 bushels, or about 1.5 per cent, of the corn crop is used in the manufacture of alcohol, lye hominy and in miscellaneous ways.

Manufacturing Processes for the Major Products

Dry process.—The corn meal mills manufacture the meal by what is known as the dry process. In the early days of corn milling, the entire kernel was ground. This made an excellent quality of corn meal, although some people objected to it because of the fine particles of hull. The greatest objection, however, was the presence of the germ in the meal, which made the meal rancid if kept a great length of time. Modern corn milling, therefore, involves degerminating the corn as its first step. The corn is sprayed with water or treated with steam until it has a moisture content of about 20 per cent, after which it goes into a machine with a rapidly revolving core, which results in breaking up the kernel in such a way as to loosen the hull and the germ but not to grind the starch. By mechanical processes, the hard starch is separated and ground into the commercial corn meal as we know it to-day, or, as some people call it, " hominy grits." If the meal is ground extremely fine, it makes what is known as corn flour, which can be mixed with wheat flour to produce a

product which is just as good as pure wheat flour, although the bread made from it does not rise quite as much.

The soft white starch is mixed with the hulls, which are commercially known as corn bran, to make what is known as hominy feed. Extensive experiments with hominy feed in Iowa and Indiana indicate that it has practically the same value for hogs as shelled corn. The germs are sometimes ground and mixed with the hominy feed; but in the more up-to-date plants the oil is pressed out. The oil cake which is left after pressing out the oil is generally mixed with the hominy feed. Under average conditions, a bushel of corn, under the dry process, produces about 22 pounds of corn meal, 33 pounds of hominy feed, and one-half pound of oil.

In the manufacture of cornflakes, the dry process is used until the coarse particles of horny starch are separated out. These are rolled out and toasted. Most of the cornflakes are manufactured by three large plants at Battle Creek, Michigan. They use about 10,000,000 bushels of corn annually.

Wet process.—The starch factories do not use quite as much corn as the corn meal mills, but the process is far more complicated, and the products are much more extensively used in a wide variety of industries. The method of manufacture is known as the wet process. A bushel of corn as manufactured in a starch factory by the wet process produces about 34 pounds of starch, 15 pounds of gluten feed, 1.5 pounds of corn oil and 1.5 pounds of corn oil cake meal. Of the 34 pounds of starch which are obtained from the ordinary bushel of corn, only about 12 pounds are usually sold by the starch factories in the form of starch. Most of the rest (about 16 pounds) is usually converted into corn syrup. Sixteen pounds of corn starch make 19 or 20 pounds of corn syrup or glucose. About 8 pounds of the original 34 pounds of starch obtained from a bushel of corn are made into a corn sugar. Both corn syrup and corn sugar are extensively used in candy making, ice cream, preserving, etc. Of the sugar used in commercial candies, over one-third comes from corn. People in the United States who eat candy are

patronizing the farmers of the Corn Belt to almost as great an extent as they are the planters of Cuba and Hawaii. The refined sugar which came into vogue in 1923 can be used very satisfactorily as a substitute for cane sugar except in jellies.

The wet milling process of corn manufacture is briefly as follows:

The corn first goes through a very thorough purification process by which dust, particles of corn cobs, nails and other impurities are removed. The corn is then steeped for about thirty-six hours in lukewarm water to which is added a small amount of sulphurous acid. This is necessary for it prevents fermentation and also softens the corn, allowing a better separation to take place later on in the process. Most of the sulphurous acid is lost in the steps to follow: The steeped corn is fed into disintegrator steel mills, which crush the kernel but do not grind it. In this crushing the elastic germ remains unbroken and is easily separated from the remainder of the kernel. This is done by passing the crushed mass into "germ separator tanks," in which the germs, containing 60 per cent oil, rise to the top and are removed by a mechanical skimming apparatus. They are then thoroughly washed with water in rotating sieves to remove all traces of gluten and starch which may adhere to them.

The lumps of endosperm, hulls and loose particles of gluten and starch leave the separator tanks as tailings. This mass, coming from the bottom of the tanks, goes to the buhr mills, in which it is ground fine. It is then pumped over revolving silk sieves, where the hulls are removed and washed free from adhering gluten and starch, which pass through the fine silk cloth. The hulls, separated in the rotating sieves, are partly dehydrated and then thoroughly dried in steam dryers. They are later mixed with the gluten to form "gluten feed."

The mixture of starch and gluten suspended in water and passing through the sieves during the separation of both the germ and hulls is run off at a regulated speed over long sloping troughs or tables. The starch being the heavier settles down

into a solid cake, while the gluten suspension runs off the tables as tailings. The gluten liquor is collected in cone settlers where it is concentrated. The concentrated liquor is filter pressed and the resulting gluten (containing about 55 per cent protein) is dried and mixed with the hulls to form " gluten feed." To this gluten feed, before it is finally dried, is also added the concentrated steepwater, containing food materials which were dissolved out from the corn.

The somewhat solid cake of starch on the tables is removed by churning it up with a heavy stream of water. The starch liquor is filter pressed and the press cake rapidly dried into so-called " pearl starch," or pulverized and sold as powdered starch. For food purposes the starch is subjected to a number of washings before it is filter pressed, dried and powdered. These starches find their way into the market in bulk or in package form under the various trade names such as " Buffalo," " Kingsford Silver Gloss," " Duryea " or " Argo Gloss." Some of these starches are also made in crystal and in lump form. For laundry purposes there are prepared various grades called " thin boiling starches." Dextrines, used for making adhesives, sizing mixtures, etc., are made from powdered starch.

Dent corn, which is used mostly by the corn products industry, contains practically no sugar of any kind. Corn sugars and syrups are made by changing, by hydrolysis, the starch into the sugar or syrup, as the case may be. The process is briefly as follows: The starch liquor from the tables is first rewashed and then pumped into large vessels capable of being subjected to high pressures. The starch liquor is heated in these convertors with a very small amount of muriatic or hydrochloric acid under a pressure of about thirty-five or forty-five pounds, depending on whether it is desired to change the starch completely into sugar or only partially to form corn syrup. After this treatment the liquor (corn sugar or syrup) is blown into large tanks, in which the muriatic acid is neutralized with soda ash. As a result of the action between the acid and soda ash there is formed a small amount of common,

harmless salt which is found in traces in all corn sugar products. After the neutralization the liquors are passed through a mechanical separation to remove the suspended matter present. To remove color these liquors are run over bone-black filters. They are then partially concentrated in vacuum pans, again decolorized with bone-black and finally concentrated by evaporation to the desired gravity.

The sugar liquor, after concentrating, is run into barrels, where it solidifies on cooling. These grades are used in many industries, among them the brewing, tanning and sugar color making. A higher grade sugar is made by running out the concentrated sugar liquors into large boxes in which it solidifies. When hardened to a certain degree it is cut into small rectangular pieces. These, after proper curing, are wrapped in press cloths and placed in hydraulic presses, where they are subjected to a high pressure. The mother liquor, containing non-crystallizable matter, is forced out. This is called " hydrol " and corresponds to molasses in the cane sugar industry. The sugar cakes are then broken up, dried and pulverized. Corn sugar produced in this way is used in baking, manufacture of chewing gum, candies, etc.

Recently a new method for the production of an extremely pure corn sugar was tried out and found to be successful. In this method the sugar is crystallized out of the sugar liquor under slow motion, and under conditions paralleling those in use for producing white cane sugar. This resulted in a sugar of 99.5 per cent purity, i.e., 99.5 per cent pure dextrose. Previously the highest purity obtained in the finished sugar was 95 per cent. This sugar, " Refined Cerelose," is only about three-fifths as sweet as cane sugar, but carries, pound per pound, fully as much value as cane sugar, and is more digestible and healthful. A slightly more purified sugar has been used recently by physicians for baby feeding experiments. The corn sugar was found to give wonderful results in this connection, and as a result many physicians are prescribing it continuously. " Refined Cerelose " has been found to be satisfactory for use

in confectionery, ice cream, and baking. Its use for condensed or evaporated milk will also prove satisfactory. Only about 5,000,000 bushels of corn were used in the manufacture of corn sugar in 1928. This amount can be greatly increased when the United States Department of Agriculture will allow it to be used without discrimination by canners.

Corn oil.—The germs, after drying, are conveyed to cylindrical steel mills and ground to a fine powder. This oil meal is heated and passed through presses. The cake from which the oil has been pressed is ground up and sold as oil cake meal. The oil run off from the presses goes through a refining process, in which it is filtered, neutralized, decolorized and clarified, deodorized with steam, chilled and again filtered. This results in the edible corn oil of commerce. It makes an excellent salad oil, which many housewives believe to be fully equal to the more expensive olive oil. It is the most valuable product on a pound basis that is produced from corn.

Corn products companies.—The Corn Products Company is the largest single factor in the wet process manufacture of corn. This is indicated in the following table, which gives in millions of bushels the corn used by all the wet corn factories as compared with the Corn Products Company alone:

	All Factories (bushels)	Corn Products Co. (bushels)
1907	39,000,000	32,000,000
1910	48,000,000	34,000,000
1914	46,000,000	28,000,000
1920	54,000,000	37,000,000
1921	58,000,000	32,000,000
1922	67,000,000	38,000,000
1923	66,000,000	36,000,000
1924	75,000,000	38,000,000
1925	70,000,000	35,000,000
1926	82,000,000	38,000,000
1927	85,000,000	40,000,000

Previous to 1907, the wet process factories were on a weak financial basis. When a large number of the plants were consolidated into the Corn Products Company, under Standard Oil guidance, the situation was not greatly changed for a time. Then the company began selling its starch, syrup, oil, etc., to the public under brand names which were well advertised. Profits jumped enormously, and since 1922 Corn Products Company common stock has sold on the New York Stock Exchange for about five times what it did previous to 1916. Previous to 1916, the profits per bushel of corn ranged from 5 to 14 cents. In 1921, the profits were 29.3 cents per bushel; 1922, 36.6 cents; 1923, 38.8 cents, and 1924, 38.2 cents. Undoubtedly, an enormously profitable business has been built on corn by the Corn Products people since the War. The Corn Products Company plants are now located at Argo and Pekin, Illinois; Kansas City, Missouri, and Edgewater, New Jersey. The three independent companies in Iowa are at Cedar Rapids, Clinton and Keokuk. Some of the independent companies are connected with the Corn Products Co. more or less indirectly.

Types of Corn for Wet and Dry Processes

It should be noticed that the corn meal mills and the starch factories are best served by different types of corn. While both appreciate a corn high in oil, the corn meal mills' chief product is made out of the horny starch, whereas the starch factories' chief product is made out of the soft starch together with a part of the horny starch. The corn meal mills sell the soft starch and the hulls as an animal feed, whereas the starch factories sell the glutinous part of the hard starch and hulls as animal feed. It would seem, therefore, that a flinty corn rich in protein would serve the corn meal mills best, whereas a rather soft corn low in protein would serve the starch factories better.

Miscellaneous Products

A bushel of corn can be made into 2.5 gallons of alcohol, and it is possible that a hundred years from now corn alcohol will be extensively used instead of gasoline to furnish motive power for automobiles and trucks. Roughly estimated, corn at 90 cents a bushel can produce alcohol to compete with gasoline at 50 cents a gallon. Before the War, about 23,000,000 bushels of corn were used annually in the distillation of alcohol, but since the Volstead act only three or four million bushels have been reported to the revenue officers as being used in the distillation of alcohol. For the time being molasses from Cuba has largely supplanted corn as a source of industrial alcohol. One of the less important but interesting corn industries is the manufacture of cob pipes. In south-central Missouri is grown one of the largest-eared varieties of corn in existence. The cobs of this Missouri cob-pipe variety sell to the pipe factory for about as much as ordinary ear corn which carries the kernels as well as the cobs. About $500,000 worth of Missouri cob pipes are sold annually.

The cobs of ordinary corn are used to some extent in the manufacture of a dye known as furfural. As yet, however, no very strong market for ordinary corn cobs has been found. Many miscellaneous products of little importance are made of the stalks and husks.

The 10 per cent of the corn crop used by American corn industries plays a more important part in making the corn market than many people suspect. These industries buy a large part of the corn which comes to such markets as Chicago, and the competition which they furnish plays an important part in setting the price. As the years go by, and people become more and more familiar with the good qualities of food products made out of corn, it is probable that these corn industries will be able to compete more and more successfully with hogs in the furnishing of a satisfactory market for the Corn Belt farmer's corn.

The Cornstalk Industry

It has long been known that paper of good quality can be made out of cornstalks but with wood pulp at present prices the paper manufacturers have not looked with kindness toward cornstalks. Experiments by O. R. Sweeny of the Iowa State College at Ames have demonstrated since the War that not only can good paper be made out of cornstalks but also rayon and wallboard. Cornstalks and spruce are possibly two of the best sources of the Alpha cellulose out of which rayon is made. Cornstalk enthusiasts have suggested that the cornstalks were actually worth more than the ears. This is probably not true. At any rate the one factory in operation at this writing in 1928 is paying about $5 an acre for the stalks and doing the gathering and hauling itself. This is $4 an acre more than the $1 which stalks are generally considered to be worth for pasture. However, a ton of stalks contains as much nitrogen as a ton of manure; 50 per cent more phosphorus, and more than twice as much potassium. If manure is worth $2 a ton, farmers should not sell their cornstalks unless they can net better than $2 a ton after all expenses.

There are great possibilities in the cornstalk industry as our timber resources become less. Wallboard made out of cornstalks is a good building material. But a widespread cornstalk industry should not be built up unless adequate provision is made for preventing the rapid inroads on soil fertility which such an industry will make. The price paid to the farmer for cornstalks must be high enough to permit the extensive purchase of commercial fertilizers.

Five years hence it will be possible to talk with greater authority on the cornstalk industry, which is apparently full of promise.

CHAPTER XXIV

PROBLEMS AND COMMUNITY STUDIES

This chapter is especially for high school and college students who want to find the way corn is being grown in their home communities and to discover methods of improvement. First, some of the simple arithmetical problems which arise out of corn growing are considered, and after that community studies of corn.

Problems in Corn Growing

1. Determine the number of hills in an acre of corn when the hills are 3 feet 6 inches apart each way. When the hills are 3 feet 4 inches by 3 feet 6 inches. When the hills are 3 feet 4 inches each way. When the hills are 3 feet each way.

Suggestions:

There are 43,560 square feet in an acre. Each hill occupies 9 square feet when the hills are 3 feet apart each way.

2. If 3 kernels to the hill ordinarily gives an average of 2.6 stalks to the hill, about how many stalks will there be on an acre with hills 3 feet 6 inches apart planted at the 3 rate? How many stalks to the acre will three plantings give with the other distances as suggested under Problem 1? If there are only two stalks saved per hill how many stalks will there be per acre at different rates of planting?

3. With 10,000 stalks per acre how many ounces of ear corn must the average plant produce to make a yield of 30 bushels per acre? Of 40 bushels? Of 50 bushels? Of 70 bushels? Of 100 bushels? Answer these same questions but assume stands of 9000, 8000, 7000, and 6000 stalks per acre.

4. If a full-grown corn plant during mid-summer evaporates 5 pounds of water daily how many tons of water will an acre of 9000 corn plants evaporate in the 30-day period from July 10 to August 9?

5. If it takes 110 tons of water to make an acre-inch, about how many inches of water are represented by the monthly evaporation as under Problem 4?

6. If a bushel of soft corn on the ear weighs 90 pounds and is 25 per cent cob and 30 per cent water, how many pounds of dry feeding matter will there be in the grain of the 90 pounds? If a bushel of No. 2 corn on the ear weighs 70 pounds and is 20 per cent cob and 16 per cent water, how many pounds of dry feeding matter will there be in the shelled corn? If the 90 pounds of soft corn can be bought for 70 cents a bushel and the 70 pounds of No. 2 corn can be bought for 90 cents a bushel, which is the better buy for winter feeding, assuming the soft corn can be stored without spoiling?

7. How many miles will a man travel in cultivating an acre of corn with the rows 3 feet 6 inches apart if he uses a one-row cultivator? If he cultivates 7 acres in an 8-hour day, what is his rate of speed per hour? If he cultivates 12 acres with a two-row cultivator in an 8-hour day what is his rate of speed per hour?

8. Allowing 40 pounds to the cubic foot of settled silage, how many tons are there in 30 feet of settled silage in a 16-foot silo? Allowing 43 pounds to the bottom third of settled silage, how many tons are there in the bottom 9 feet of a 14-foot silo?

Studying Corn in a Community

In order to form practical corn judgment it is necessary to find out just how the practical farmers are growing corn in a community. It will be found that different farmers grow corn in different ways. In order to develop the direct contact between the student and the corn as it is actually grown, it is suggested that three different blanks should be filled out. To fill out the first blank the student should interview his father or some corn farmer in the neighborhood. Following is the first blank.

BLANK I

Collecting Corn Information from the Farmer Regarding a Particular Corn Field

What is the soil type?.....
What crop was grown on this field last year?.....
Two years ago?.....
Three years ago?.....

Four years ago?.....
Five years ago?.....
How much manure, lime or other fertilizer was spread on this field last year?.....
Two years ago?.....
Three years ago?.....
Four years ago?.....
Five years ago?.....
Taking both soil type and soil treatment into account, what percentage is this field above or below average?.....
What variety of corn was planted on this field?.....
Where did the seed corn come from originally?.....
Is it a big-eared, medium-eared, or small-eared type of corn?.....
How was the seed picked and stored?.....
Ask the farmer for three ears illustrating the type of seed corn he likes.....
Was the seed treated with commercial dust?.....
When was the field planted?.....
How far apart each way were the hills spaced?.....
How many times was the corn cultivated?.....
What is the farmer's estimate of the yield per acre?.....
What was the rainfall and temperature like during the summer?.....
Any particular items of interest offered by the farmer.....
.....

Too few farmers and farmers' boys give corn an intensive study in the field in September and October. The most important thing to be learned is whether the stand was too thick or too thin to utilize to the best advantage the soil fertility, the rainfall, and the type of corn. The information as to soil fertility, rainfall, type of corn, etc., is found in the answers to the questions of Blank I. The problem as set forth in Blank II is to go into the field and count the stalks in representative hills in different parts of the field and then finally to make an estimate of the total number of stalks in an acre. After weighing all of the information, a conclusion should finally be reached as to whether the stand in the particular field was too thick or too thin in order to obtain the maximum yield of sound corn.

In the last part of Blank II will be noted the question, "How many pounds does the ear corn from fifty hills weigh?" When corn is thoroughly matured and it takes only 70 pounds

of ear corn to make a bushel and when the hills are 3 feet 6 inches apart each way, the number of pounds of ear corn from 50 representative hills gives a fairly accurate line on the number of bushels of yield per acre. In other words, if the ear corn from fifty hills weighs 60 pounds then it would be assumed that the field was yielding around 60 bushels to the acre. Of course in late September when the corn is so wet that it oftentimes takes 90 pounds of ear corn to make a bushel the yield of 38 or 39 hills of corn in pounds will come closer to giving the true yield in bushels per acre. It is an interesting school project to take a sample from a field of corn in late September or early October, weigh it immediately after it is taken from the field and then hang it up in a dry room and weigh it three weeks later after the water has dried out and then calculate the percentage of shrinkage.

Blank II which is based on the idea of using the corn field as the laboratory follows.

BLANK II

Collecting Corn Information about a Particular Field by Field Study in September and October

How many stalks are there in 70 representative hills?.....
How many smutted stalks are there in 70 representative hills?.....
How many two-eared stalks are there in 70 representative hills?.....
How many barren stalks are there in 70 representative hills?.....
On the basis of the above sample how many stalks are there per acre?....
On that basis, how many smutted stalks are there per acre?.....
On the same basis how many two-eared stalks are there per acre?.....
On the same basis, how many barren stalks are there per acre?.....
How many pounds does the ear corn from 50 hills weigh?.....
How many pounds should be allowed to the bushel of ear corn at the time this weight is taken?.....
Allowing 70, 80, 90 or whatever number of pounds is about right, what is the indicated yield per acre from the 50-hill sample?.....

The questions in Blank III are best answered by the students during the winter months. The idea is to study crib-run corn as it exists in the average farmer's crib. One hundred

pounds of average corn should be taken out of the crib with a scoop shovel in such a way that there is an absolutely fair sample and this corn should be brought into the school house or some other place where the questions in Blank III can be answered. If the student, as a result of Blank I, is able to have on hand three ears illustrating the type of seed corn the farmer likes to plant, he will find it interesting to compare these with the field run. The seed ears, in the central part of the Corn Belt, will average about a pound in weight, whereas the average ear as it comes from the field will only average about a half a pound. The most important thing of all is to shell the corn and give it a commercial grade based on the moisture test and the test weight per bushel. Special apparatus is needed for determining both moisture and test weight per bushel. In case such apparatus is not available in the school it may be possible to have these points bearing on the government grade determined by sending a pound sample to some elevator or Board of Trade where there is the necessary equipment for making such tests. In some cases the tests may be made free of charge but in other cases as much as a dollar will be charged. Blank III follows.

BLANK III

Collecting Corn Information from 100 Pounds of Average Crib-run Corn from a Specified Field

How many ears are there in 100 pounds of crib-run corn?.....
What does the average ear weigh in ounces?.....
    How many of the ears weigh less than 5 ounces?.....
    How many of the ears weigh from 5 to 8 ounces?.....
    How many of the ears weigh over 8 ounces?.....
How many of the ears carry 14 rows or less?.....
    How many of the ears carry 16 rows?.....
    How many of the ears carry 18 rows?.....
    How many of the ears carry 20 rows?.....
    How many of the ears carry 22 rows or more?.....
How many of the ears are smooth?.....
How many of the ears are medium?.....
How many of the ears are rough?.....

What is the shelling percentage of the smooth ears?.....
Of the medium ears?.....
Of the rough ears?.....
What is the moisture percentage of the shelled corn from the smooth ears?
The medium ears?.....
The rough ears?.....
What is the test weight per bushel of the shelled corn from the smooth ears?
.....
The medium ears?.....
The rough ears?.....
What is the commercial grade and probable price per bushel at Chicago of the shelled corn from the smooth ears?.....
The medium ears?.....
The rough ears?.....
How many kernels are there in an ounce of the shelled corn?.....
Out of 100 representative kernels as taken from the sheller, how many are bright and shiny and how many are dull and starchy?.....

The most interesting information will come after the different students have filled out these different blanks and it is possible to tabulate side by side the information from at least half a dozen different cornfields. Then it is possible to make a detailed study to see to what extent the high-yielding fields owe their yield to a good stand and to what extent to soil fertility. It is interesting to study to what extent the high-yielding fields have the largest ears. Do the high-yielding fields have a higher percentage of smooth ears or a higher percentage of rough ears? To what extent does early planting influence the commercial grade of the corn? What is the influence of soil fertility on the commercial grade of the corn? In studying all of these things out, it will be found occasionally that there is no theory which adequately explains the results. Perhaps the students who fill out blanks of this sort will discover things which none of the professors and experimenters have ever known before.

Improving Community Practices

The teacher of vocational agriculture will find it worth while to stimulate community corn enterprises. Hitherto the easiest

thing to do has been to put on a corn show. Corn shows are all right as far as they go and they stir up considerable interest.

A new kind of corn show which vocational teachers can work out for themselves to fit their local situation is based on the idea of crib-run corn somewhat as presented under Blank III in this chapter. Let the competing corn be brought in on the ear just as it comes from the crib without any selection and then let it be shelled and finally judged on a shelled basis The standard of judgment would be the commercial grade and what the Chicago market would pay for it. In such a corn show, the shelling percentage, moisture determination, and test weight per bushel would ideally be done by the students in the high school. An exhibit might be held and in holding the exhibit the percentage of moisture, test weight per bushel, shelling percentage, etc., would be placed on each sample. It would be interesting, of course, if five or six ears which were not shelled could be exhibited along with these samples. These ears would of course have nothing to do with the determination of the awards but would merely give an idea as to how each man's corn looked on the ear.

Another community corn project which is very successful in years when the seed corn situation is bad is to do a considerable amount of rag-doll testing for different farmers during February and March. A conscientious teacher of vocational agriculture can oftentimes wake up a community to a grave seed corn danger by putting on a seed-corn testing campaign through his pupils.

Finally a corn meeting can be held in the late winter at which the results of the student study as obtained from Blanks I, II, and III can be set forth for the benefit of the practical farmer. And better yet the practical farmers can suggest ways in which the blanks can be improved to bring out ideas which the students have not discovered. Discussions can be held as to the proper number of stalks per acre to fit soils of different fertility in different kinds of seasons when planted with different types of corn.

A community enterprise which only a few vocational teachers will care to undertake is the seed corn cross-breeding project. The crossing of inbred strains of corn will from now on be coming more and more into the public eye. Certain vocational agricultural teachers who have a plot of ground convenient to the school will want to plant different inbred strains of corn and cross them in cooperation with some of the pupils. The seed thus crossed can be given in 2- or 3-pound lots to different farmers to try out the following year in comparison with their home varieties of corn.

A multitude of community corn projects will suggest themselves to the vocational agricultural teacher. In time he will discover certain things which are hidden to-day even from our most advanced research workers in corn.

CHAPTER XXV

CORN STATISTICS

Most of the statistics in the following are compiled from records of the U. S. Department of Agriculture. Students who wish to keep these tables up-to-date should consult future year-books of the U. S. D. A. and the monthly publication Crops and Markets.

The farm crops teacher, whether in high school or college, will find it possible to organize a number of research projects as the basis of these tables. For instance the students can study for themselves the relationship between corn prices and corn yields. Moreover the relationship of weather records to corn yields can be studied. The geographical distribution of corn prices in different kinds of crop years can be investigated. We will call especial attention to the last table in this chapter dealing with corn quality in different years in the different states. The way in which this is influenced by weather is well worth careful study.

World Corn Acreage Before the War and Since

Country	Average 1909–1913[1]	1924	1925	1926	1927
Northern Hemisphere	1000 Acres	1000 Acres	1000 Acres	1000 Acres	1000 Acres
North America					
Canada	309	295	239	210	132
United States	104,229	101,863	101,359	99,713	97,638
Mexico	6,093[2]	8,072	9,244	7,484	
Guatemala	(500)	426	383	253	278
Total North American countries reporting area and production, all years shown	105,038	102,584	101,981	100,176	98,048
Estimated North American total	111,700	111,400	112,100	108,400	106,800
Europe					
France	1,160	846	854	834	752
Spain	1,134	1,162	1,170	1,006	1,099
Portugal	.....	800	.....	811	
Italy	4,090	3,806	3,840	3,767	3,954
Switzerland	3	4	4	3	3
Austria	190	147	149	153	151
Czechoslovakia	376	389	387	388	394
Hungary	2,192	2,459	2,655	2,631	2,589
Yugoslavia	4,786	4,857	5,119	4,929	5,557
Greece	454[2]	470			
Bulgaria	1,492	1,505	1,582	1,470	1,661
Rumania	9,644[4]	8,940	9,713	10,031	10,427
Poland	164	190	192	195	196
Russia, European and Asiatic	3,246	5,049	7,674	7,037	
Total European countries reporting area and production, all years shown	25,067	24,124	25,473	25,212	26,587
Estimated European total, excluding Russia	26,400	25,600	26,900	26,700	28,000
Africa					
Morocco	(438)	493	515	562	692
Algeria	34	25	26	27	
Tunis	43[5]	41	56	54	37
Egypt	1,705[5]	1,878	2,076		
Estimated African total	2,600	3,400	3,700	3,500	

WORLD CORN ACREAGE BEFORE THE WAR AND SINCE—*Continued*

Country	Average 1909–1913 [1]	1924	1925	1926	1927
NORTHERN HEMISPHERE *Continued—Asia*	1000 Acres	1000 Acres	1000 Acres	1000 Acres	1000 Acres
Turkey	872[2]	661	1,001	377	
India	5,898[3]	5,824	5,312	5,439	
Japanese Empire:					
Japan	133	140	137		
Chosen	156	229	241	245	
Kwantung	99	203	200		
Philippines	812[2]	1,318	1,291		
Estimated Asiatic Total	9,300	10,200	10,100		
Total Northern Hemisphere countries reporting area and production, all years shown	130,586	127,242	128,025	126,044	125,364
Estimated Northern Hemisphere Total, excluding Russia	150,000	150,600	152,800	148,200	148,000
SOUTHERN HEMISPHERE					
Paraguay	30	107	114		
Brazil	(6,000)	6,178	6,301	6,919	
Chile	56	42	58	58	
Uruguay	589	406	436	391	
Argentina	8,710	9,162	10,618	9,061	
Union of South Africa	2,290[2]	5,333	(4,604)	3,562	
Southern Rhodesia	161	239	240	261	
Java and Madura	(3,000)	4,356	4,847	4,840	
Australia	353	399	297		
New Zealand	5[4]	9	9	10	
Nyasaland	1	3	4	4	
Southern Hemisphere countries reporting area and production, all years shown through 1926	20,812	25,728	27,117	25,106	
Estimated Southern Hemisphere total	21,900	28,500	29,800	27,700	
Northern and Southern Hemisphere total, all countries reporting area and production, all years shown through 1926	163,587	167,081	169,916	164,253	
Estimated world total, excluding Russia	171,900	179,100	182,600	175,900	

Official sources and International Institute of Agriculture. Figures refer to the crop harvested in the calendar year in the Northern Hemisphere and the succeeding harvest in the Southern Hemisphere.

[1] Where changes in boundary have occurred, the averages reported are estimates for the crop within present boundaries.

[2] One year only. [3] Two-year average. [4] Four-year average. [5] Includes some sorghum

Country	Year Ended June 30					
	Average, 1910–1914		1926		1927 Preliminary	
	Imports, 1000 Bushels	Exports, 1000 Bushels	Imports, 1000 Bushels	Exports, 1000 Bushels	Imports, 1000 Bushels	Exports, 1000 Bushels
Principal Exporting Countries						
Argentina	2 [1]	115,749 [1]	2 [2]	142,956	7 [2]	272,373
Australia	440 [1]	10 [1]	.....	55 [3]	1,314 [3]	
British India	.....	580 [1, 4]	.....	38	.....	2
Bulgaria	44 [1]	9,234 [5]	.....	3,799	.....	5,365
China [2]	38 [6]	148 [6]	.....	758	.....	983
Dutch East Indies	.....	1,215 [1]	.....	736 [3, 7]	.....	1,256 [3, 8]
French Indo-China [3]	.....	.....	.....	2,374	.....	2,688
Hungary	.....	.....	46	8,752	330	2,524
Rumania	364 [1, 9]	46,998 [1, 9]	21	21,239	.....	55,923 [3, 7]
Russia	299 [5]	28,354 [5]	.....	7,867	.....	9,033 [10]
Syria and Lebanon	.....	.....	.....	26 [3, 10]	.....	79 [3, 7]
Union of South Africa	143 [1]	3,952 [1]	20 [2]	40,380	23 [2]	1,430
United States	4,441 [9]	41,409	635	24,783	1,098	19,820
Yugoslavia [3]	.....	.....	.....	41,122	.....	13,173 [8]
Principal Importing Countries						
Algeria	231 [1]	1 [1]	65	10	600	12
Austria	15,455 [5, 16]	265 [5, 16]	6,387	19	7,946	18
Belgium	25,818	8,238	22,588	655	26,872	1,502
Canada	10,678	27	9,325	62	14,924	56
Czechoslovakia	.....	.....	13,824	12	13,074	2
Cuba	2,860	[11]	3,103	.....	1,285 [12]	

Denmark	11,777 [5]	[11]	16,198	.....	22,727	
Egypt	504 [5]	63 [5]	944	[11]	294	235
Esthonia [3]	.....	.....	16			
Finland	260 [1]	.....	44	.....	148	
France	19,793	88	21,326	108	22,134 [13]	62 [13]
Germany	32,056	2	19,679	103	57,910	4
Greece	.....	.....	87 [3, 14]			
Irish Free State	.....	.....	14,127	92	15,679	172
Italy	14,829	265	14,232	119	16,134	23
Japan [3]	.....	.....	558	.....	1,511	
Latvia [3]	.....	.....	20	.....	8	
Mexico	1,120 [5]	7 [5, 15]	4,388 [12]	9 [12]		
Netherlands	30,377 [5]	8,641 [5]	38,965	443	47,153	736
Norway	1,292 [5, 15]	.....	4,497	.....	5,048	
Poland [2]	.....	.....	1,792	65	4,235	21
Portugal	1,833 [5]	11 [5]				
Spain	2,023	49	18,547	1	8,823 [13]	[11]
Sweden	1,656 [5]	26	3,771	.....	4,652	
Switzerland	3,984 [5]	1	5,539	[11]	4,832	[11]
Tunis	442 [5]	8 [5]	291	23	390 [13]	35 [13]
United Kingdom	80,441	115 [1]	70,914	2,593	71,542	2,794
Uruguay [2]	5	201	97	43	.....	2 [12]
Total, 42 countries	263,205	265,655	292,048	299,242	350,693	390,323

Official sources except where otherwise noted. Maicena or maizena is included with "Corn and corn meal."

[1] Average of years ended December 31, International Yearbook of Agricultural Statistics.
[2] Year ended December 31.
[3] International Crop Report and Agricultural Statistics.
[4] Two-year average.
[5] Average of years ended July 31, from International Institute of Agriculture sources.
[6] Four-year average.
[7] Eight months.
[8] Ten months.
[9] Three-year average.
[10] Eleven months.
[11] Less than 500 bushels.
[12] Six months.
[13] Nine months.
[14] Two months.
[15] One year only.
[16] The average shown for 1910–14 is for Austria–Hungary.

Corn: Domestic Exports from the United States by Countries, 1910–1927

Compiled from Foreign Commerce and Navigation of the United States, 1910–1918, Monthly Summary of Foreign Commerce of the United States, June issues, 1920–1926, and official records of the Bureau of Foreign and Domestic Commerce.

Year Ended June 30	United Kingdom	Netherlands	Canada	Germany	Mexico	Cuba	Denmark	Belgium	France	Italy	Other Countries	Total
	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels	1000 Bushels
1910	10,668	5,185	6,179	4,537	3,258	2,377	2,451	1,144	446	0	557	36,802
1911	17,723	7,147	13,410	7,971	7,067	2,225	3,083	2,681	1,626	51	777	63,761
1912	10,616	5,658	9,569	6,801	1,168	2,118	1,546	1,407	452	4	700	40,039
1913	14,983	7,192	8,098	6,546	543	2,373	5,390	1,648	442	4	1,846	49,065
1914	541	374	4,642	303	467	2,410	[1]	60	55	0	529	9,381
1915	2,850	15,876	8,283	16	1,587	2,267	11,170	104	3,773	70	2,790	48,786
1916	5,627	5,706	6,568	0	3,679	3,231	9,527	5	2,560	[1]	1,314	38,217
1917	24,494	7,924	15,725	0	2,531	2,819	7,075	581	1,533	1,157	882	64,721
1918	21,198	246	7,896	0	3,273	1,142	0	3,714	1,417	2,018	94	40,998
1919	2,522	100	8,940	0	1,215	1,454	334	1,568	2	350	203	16,688
1920	2,169	0	9,929	0	61	2,031	1	1	191	0	85	14,468
1921	11,423	10,144	20,298	10,844	5,635	2,121	4,401	955	165	27	898	66,911
1922	22,074	22,840	61,643	27,175	10,102	2,694	7,266	4,471	2,975	1,428	13,718	176,386
1923	21,271	13,962	32,154	11,807	288	2,778	3,320	1,931	3,174	861	2,418	94,064
1924	4,449	2,369	8,258	673	337	2,615	866	564	380	[1]	655	21,186
1925	141	77	4,239	26	1,366	2,267	0	0	5	[1]	339	8,460
1926	2,378	3,510	8,071	742	4,453	2,097	999	9	110	0	768	23,137
1927	1,268	560	10,536	2	2,124	2,016	553	69	12	24	399	17,563

[1] Less than 500 bushels.

CORN: IMPORTS INTO THE UNITED KINGDOM, BY COUNTRIES, AVERAGE 1909–1913, ANNUAL 1923–1927

Compiled from Annual Statement of Trade of the United Kingdom, average 1909–1913 and annual 1923–1926; and Accounts Relating to Trade and Navigation of the United Kingdom, December issue, 1927.

Country	Year Ended December 31		
	Average 1909–1913	1926	1927 Preliminary
	Bushels	Bushels	Bushels
Argentina	45,495,513	50,178,278	71,279,506
United States	13,580,470	2,178,620	1,187,660
Rumania	10,652,760	4,322,762	2,503,930
Russia	7,488,758	1,322,418	[1]
British South Africa	1,669,978	3,691,666	3,995,024
British India	1,421,760	.....	[1]
Canada	1,085,320	111,676	[1]
Portuguese East Africa	[1]	42,840	[1]
Kenya	[1]	613,478	[1]
Belgium	[1]	487,472	[1]
Bulgaria	939,400	204,814	[1]
Uruguay	59,720	68,200	[1]
Other countries	813,688	345,312	4,897,382
Total	83,207,367	63,567,536	83,863,502

[1] If any, included in "Other countries."

Corn Acreage, Production, Value and Exports in the United States, 1849–1927

Note.—Figures in bold face are census returns; figures in roman are estimates of the Department of Agriculture. Estimates of acres are obtained by applying estimated percentages of increase or decrease to the published acreage of the preceding year, except that a revised base is used for applying percentage estimates whenever new census data are available. Acreages have been revised for years 1890–1908, so as to be consistent with the following as well as the preceding census acreage, and total production and farm values are adjusted accordingly.

Year	Acreage, in Thousands	Average Yield per Acre, Bushels	Production, 1000 Bushels	Average Farm Price per Bushel, Dec. 1, Cents	Farm Value, Dec. 1, 1000 Dollars	Domestic Exports, Including Corn Meal, Fiscal Year Beginning July 1 (Bushels)
1849	.....	.....	**592,071**	.....	.....	7,632,860
1859	.....	.....	**838,798**	.....	.....	4,248,991
1866–1875	37,216	26.1	969,948	46.9	454,535	24,242,396
1876–1885	61,671	25.4	1,564,992	39.5	617,780	69,091,110
1886–1895	74,274	23.8	1,769,616	36.7	648,785	59,293,085
1896	86,560	28.9	2,503,484	21.3	532,884	178,817,417
1897	88,127	24.3	2,144,553	26.0	558,309	212,055,543
1898	88,304	25.6	2,261,119	28.4	642,747	177,255,046
1899	**94,914**	25.9	2,454,628	29.9	734,916	213,123,412
1900	95,042	26.4	2,505,148	35.1	878,243	181,405,473
1901	94,636	17.0	1,613,528	60.1	969,285	28,028,688
1902	95,517	27.4	2,619,499	40.1	1,049,791	76,639,261
1903	90,661	25.9	2,346,897	42.1	987,882	58,222,061
1904	93,340	27.1	2,528,662	43.7	1,105,690	90,293,483
1905	93,573	29.4	2,748,949	40.8	1,120,513	119,893,833
1906	93,643	30.9	2,897,662	39.3	1,138,053	86,368,228
1907	94,971	26.5	2,512,065	50.9	1,277,607	55,063,860
1908	95,603	26.6	2,544,957	60.0	1,527,679	37,665,040
1909	**98,383**	26.1	2,572,336	58.6	1,507,185	38,128,498
1910 [1]	104,035	27.7	2,886,260	48.0	1,384,817	65,614,522
1911	105,825	23.9	2,531,488	61.8	1,565,258	41,797,291
1912	107,083	29.2	3,124,746	48.7	1,520,454	50,780,143
1913	105,820	23.1	2,446,988	69.1	1,692,092	10,725,819
1914	103,435	25.8	2,672,804	64.4	1,722,070	50,668,303
1915	106,197	28.2	2,994,793	57.5	1,722,680	39,896,928
1916	105,296	24.4	2,566,927	88.9	2,280,729	66,753,294
1917	116,730	26.3	3,065,233	127.9	3,920,228	49,073,263
1918	104,467	24.0	2,502,665	136.5	3,416,240	23,018,822
1919	97,170	28.9	2,811,302	134.5	3,780,597	16,728,746
1920 [1]	101,699	31.5	3,208,584	67.0	2,150,332	70,905,781
1921	103,740	29.6	3,068,569	42.3	1,297,213	179,514,442
1922 [1]	102,428	28.2	2,890,712	65.7	1,900,287	96,596,221
1923	104,324	29.3	3,053,557	72.6	2,217,229	23,135,200
1924	100,863	22.9	2,309,414	98.2	2,266,771	9,791,136
1925	101,359	28.8	2,916,961	67.4	1,966,761	24,782,557
1926	99,713	27.0	2,692,217	64.2	1,729,457	19,819,000
1927	98,914	28.2	2,786,288	72.3	2,014,725	
1928 [2]	102,380					

[1] Acreage adjusted to census basis.

[2] Preliminary report.

Corn Production and Distribution in the United States, 1897–1927

Year	Old Stock on Farms, Nov. 1, 1000 Bushels	New Crop, Quantity, 1000 Bushels	Quality, Per Cent	Proportion Merchantable, Per Cent	Quantity Merchantable, 1000 Bushels	Total Supplies 1000 Bushels	Stock on Farms March 1, Following, 1000 Bushels	Shipped Out of County Where Grown, 1000 Bushels
1897–1901	166,809	2,195,795	83.3	85.6	2,005,697	2,362,604	823,739	424,894
1902–1906	91,662	2,628,334	88.1	82.2	2,170,417	2,719,996	1,045,965	596,400
1907	129,786	2,512,065	82.8	77.2	1,939,877	2,641,851	931,503	470,046
1908	69,251	2,544,957	86.9	88.2	2,244,571	2,614,208	999,235	565,510
1909	77,403	2,572,336	84.2	82.7	2,126,965	2,649,739	980,848	620,057
1910	113,919	2,886,260	87.2	86.4	2,492,763	3,000,179	1,165,378	661,777
1911	123,824	2,531,488	80.6	80.1	2,027,922	2,655,312	884,059	517,766
1912	64,764	3,124,746	85.5	85.0	2,654,907	3,189,510	1,290,642	680,831
1913	137,972	2,446,988	82.2	80.1	1,961,058	2,584,960	866,352	422,059
1914	80,046	2,672,804	85.1	84.5	2,259,755	2,752,850	910,894	498,285
1915	96,009	2,994,793	77.2	71.1	2,127,965	3,090,802	1,116,559	560,824
1916	87,908	2,566,927	83.8	83.9	2,154,487	2,654,835	782,303	450,589
1917	34,448	3,065,233	75.2	60.0	1,837,728	3,099,681	1,253,290	678,027
1918	114,678	2,502,665	85.6	82.4	2,062,041	2,617,343	855,269	362,589
1919	69,835	2,811,302	89.1	87.1	2,448,204	2,881,137	1,045,575	470,328
1920	139,083	3,208,584	89.6	86.9	2,789,720	3,347,667	1,564,832	705,481
1921	285,769	3,068,569	84.0	87.5	2,684,634	3,353,338	1,305,559	587,893
1922	177,287	2,906,020	85.0	88.3	2,567,044	3,083,307	1,093,306	518,779
1923	83,856	3,053,557	79.4	80.8	2,467,763	3,137,413	1,153,847	600,745
1924	102,429	2,309,414	63.2	66.0	1,523,740	2,411,843	757,890	417,780
1925	58,248	2,916,961	83.6	78.8	2,298,927	2,975,209	1,329,581	578,551
1926	183,015	2,692,217	72.6	71.1	.....	2,828,046	1,134,370	447,102
1927 [1]	113,412	2,786,288	75.2	73.4	.....	.....	1,020,335	505,621

[1] Preliminary estimate

Monthly Marketings of Corn by Farmers, 1907–1927. Per Cent of Year's Sales

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Year
1907–1908	5.3	4.0	3.4	3.8	8.8	12.2	14.2	16.1	13.7	7.1	5.6	5.8	100
1908–1909	6.7	6.8	8.4	6.7	7.3	12.1	15.0	7.2	7.5	8.2	8.0	6.1	100
1909–1910	5.7	6.6	7.2	8.0	10.2	13.7	13.3	10.5	6.2	4.4	7.8	6.4	100
1910–1911	4.6	6.1	5.9	6.9	10.5	15.7	12.2	10.1	8.4	5.2	7.8	6.6	100
1911–1912	4.7	5.6	4.4	5.5	12.6	15.2	14.5	11.7	7.4	6.5	6.4	5.5	100
1912–1913	4.1	5.1	6.1	6.5	10.5	16.9	13.3	12.6	5.9	4.2	7.0	7.8	100
1913–1914	5.8	3.3	4.5	7.9	17.8	21.4	10.7	7.1	6.3	4.4	6.2	4.6	100
1914–1915	3.9	7.1	4.7	4.7	14.7	16.8	19.8	7.8	4.6	5.6	4.4	5.9	100
1915–1916	5.6	5.9	6.4	6.0	10.4	15.9	11.7	12.4	7.1	6.4	6.3	5.9	100
1916–1917	6.2	7.1	5.9	5.3	14.0	12.5	15.1	9.0	7.0	5.4	6.5	6.0	100
1917–1918	5.3	4.0	3.4	3.8	8.8	12.2	14.2	16.1	13.7	7.1	5.6	5.8	100
1918–1919	6.7	6.9	8.4	6.7	7.3	12.0	15.0	7.2	7.5	8.2	8.0	6.1	100
1919–1920	4.5	5.6	4.9	5.6	9.2	15.0	12.9	9.5	8.7	5.9	7.6	10.6	100
1920–1921	5.4	5.6	6.9	5.3	7.1	11.3	14.3	11.7	8.9	5.6	8.5	9.4	100
1921–1922	4.9	7.3	8.6	6.7	6.6	12.4	13.8	12.4	7.5	4.7	7.6	7.5	100
1922–1923	6.8	7.5	9.1	8.2	8.7	13.6	10.7	11.0	6.6	5.3	6.1	6.4	100
1923–1924	6.8	7.2	6.1	5.6	10.4	12.3	12.9	13.3	7.4	6.1	5.9	6.0	100
1924–1925	6.6	6.2	6.5	7.0	11.1	13.0	13.6	9.5	8.1	6.3	7.8	4.3	100
1925–1926	5.1	7.6	5.9	5.9	9.3	14.6	12.1	10.4	8.5	5.3	7.1	8.2	100
1926–1927	5.8	6.2	6.8	10.3	8.8	12.5	11.6	10.8	6.9	4.8	6.2	9.3	100

Visible Supply of Corn the First of Each Month for Ten Years

Stocks in granary at principal points of accumulation at lake and seaboard ports, and in transit by water.

Month.....	1927	1926	1925	1924	1923
January.....	34,512,000	17,861,000	18,573,000	9,708,000	16,885,000
February....	41,566,000	29,718,000	27,571,000	9,379,000	21,658,000
March.....	47,337,000	35,213,000	32,292,000	18,898,000	27,529,000
April.....	47,244,000	36,485,000	32,727,000	26,074,000	28,742,000
May.....	36,621,000	32,408,000	23,379,000	17,978,000	22,339,000
June.....	29,961,000	26,569,000	17,140,000	12,288,000	6,734,000
July.....	34,427,000	30,333,000	15,021,000	8,279,000	3,366,000
August.....	30,205,000	24,930,000	6,093,000	4,887,000	1,930,000
September...	22,312,000	19,771,000	6,689,000	5,070,000	1,587,000
October.....	23,687,000	17,381,000	5,470,000	7,154,000	2,052,000
November...	20,574,000	22,258,000	1,790,000	8,097,000	809,000
December...	19,216,000	28,699,000	2,461,000	7,563,000	2,690,000

Month	1922	1921	1920	1919	1918
January.....	23,279,000	5,409,000	2,921,000	2,415,000	3,155,000
February....	26,729,000	14,297,000	3,575,000	5,549,000	4,623,000
March.....	40,897,000	22,333,000	4,951,000	4,483,000	8,939,000
April.....	46,889,000	32,896,000	5,686,000	2,514,000	19,016,000
May.....	35,564,000	23,018,000	5,035,000	4,245,000	16,111,000
June.....	27,046,000	15,103,000	2,740,000	2,600,000	13,038,000
July.....	29,337,000	24,304,000	3,372,000	4,038,000	11,487,000
August.....	19,509,000	14,584,000	6,152,000	2,461,000	9,466,000
September...	7,314,000	11,500,000	2,898,000	956,000	5,232,000
October.....	12,206,000	11,765,000	7,587,000	2,163,000	5,503,000
November...	9,087,000	18,935,000	10,085,000	1,484,000	4,733,000
December...	11,072,000	15,518,000	5,634,000	1,477,000	2,216,000

Monthly and Yearly Receipts of Corn at Primary Markets, 1913–14 to 1921–22

(In Thousands of Bushels)

Month	1913–1914	1914–1915	1915–1916	1916–1917	1917–1918	1918–1919	1919–1920
November	12,485	23,165	17,614	21,645	13,412	16,113	13,232
December	38,552	42,230	26,414	27,515	18,357	17,381	22,205
January	27,763	47,599	30,362	32,398	24,551	12,405	21,239
February	23,500	25,877	36,413	21,129	39,150	12,792	24,169
March	24,988	13,016	24,173	22,466	49,591	17,843	22,969
April	9,948	13,749	16,665	15,992	28,294	9,178	10,669
May	10,784	12,554	17,768	16,332	19,010	19,560	10,894
June	24,322	14,918	13,919	23,029	19,163	12,275	25,763
July	12,313	14,367	21,275	17,155	22,292	27,125	20,102
August	20,032	13,767	15,427	14,145	16,622	8,229	9,264
September	15,031	17,191	18,359	8,361	22,746	14,809	19,852
October	10,899	15,245	12,149	8,209	23,740	11,849	18,707
Crop year total	230,617	254,678	250,538	228,376	296,928	179,559	223,065

Month	1920–1921	1921–1922	1922–1923	1923–1924	1924–1925	1925–1926	1926–1927
November	10,374	14,105	21,882	21,791			
December	18,276	42,639	35,814	35,472			
January	39,991	46,537	34,583	28,418			
February	26,026	59,558	29,556	42,346			
March	32,514	33,930	22,987	27,799			
April	11,192	13,188	15,602	16,289			
May	19,196	21,965	10,002	14,797			
June	34,463	35,281	13,263	16,030			
July	17,949	22,475	16,868	16,456			
August	30,061	24,708	19,399	16,993			
September	35,578	31,123	16,966	20,705			
October	34,502	28,651	15,202	17,986			
Crop year total	310,122	374,160	252,124	275,082	202,225	226,192	217,754

YIELD PER ACRE OF CORN BELT STATES AND UNITED STATES *

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
1891	32.0	33.3	33.5	26.5	36.7	29.9	22.5	35.2	26.7	27.0
1892	29.4	29.3	26.2	27.0	28.3	27.7	22.3	28.2	24.5	23.1
1893	23.8	24.7	25.7	28.3	33.9	27.9	23.7	25.2	21.3	22.5
1894	26.3	28.9	28.8	18.4	15.0	22.0	4.2	6.0	11.2	19.4
1895	32.6	32.8	37.4	31.2	35.1	36.0	11.1	16.1	24.3	26.2
1896	41.0	35.0	40.5	30.5	39.0	27.0	26.0	37.5	28.0	28.2
1897	32.5	30.0	32.5	26.0	29.0	26.0	24.0	30.0	18.0	23.8
1898	37.0	36.0	30.0	32.0	35.0	26.0	28.0	21.0	16.0	24.8
1899	36.0	38.0	36.0	33.0	31.0	26.0	26.0	28.0	27.0	25.3
1900	37.0	38.0	37.0	33.0	38.0	28.0	27.0	36.0	19.0	25.3
1901	26.1	19.8	21.4	26.3	25.0	10.1	21.0	14.1	7.8	16.7
1902	38.0	37.9	38.7	22.8	32.0	39.0	18.9	32.3	29.9	26.8
1903	29.6	33.2	32.2	28.3	28.0	32.4	27.2	26.0	25.6	25.5
1904	32.5	31.5	36.5	26.9	32.6	26.2	28.1	32.8	20.9	26.8
1905	37.8	40.7	39.8	32.5	34.8	33.8	31.8	32.8	27.7	28.8
1906	42.6	39.6	36.1	33.6	39.5	32.3	33.5	34.1	28.9	30.3
1907	34.6	36.0	36.0	27.0	29.5	31.0	25.5	24.0	22.1	25.9
1908	38.5	30.3	31.6	29.0	31.7	27.0	29.7	27.0	22.0	26.2
1909	39.5	40.0	35.9	34.8	31.5	26.4	31.7	24.8	19.9	26.1
1910	36.5	39.3	39.1	32.7	36.3	33.0	25.0	25.8	19.0	27.7
1911	38.6	36.0	33.0	33.7	31.0	26.0	22.0	21.0	14.5	23.9
1912	42.8	40.3	40.0	34.5	43.0	32.0	30.6	24.0	23.0	29.2
1913	37.5	36.0	27.0	40.0	34.0	17.5	25.5	15.0	3.2	23.1
1914	39.1	33.0	29.0	35.0	38.0	22.0	26.0	24.5	18.5	25.8
1915	41.5	38.0	36.0	23.0	30.0	29.5	29.0	30.0	31.0	28.2
1916	31.5	34.0	29.5	33.5	36.5	19.5	28.5	26.0	10.0	24.4
1917	38.0	36.0	38.0	30.0	37.0	35.0	28.0	27.0	13.0	26.3
1918	36.0	33.0	35.5	40.0	36.0	20.0	34.0	17.7	7.1	24.0
1919	43.0	37.0	36.0	40.0	41.6	27.0	28.5	26.2	15.2	28.9
1920	43.4	40.5	34.6	37.5	46.0	32.0	30.0	33.8	26.5	31.5
1921	41.0	36.0	34.0	41.0	43.0	30.0	32.0	28.0	22.2	29.7
1922	39.0	37.0	35.5	33.0	45.0	28.5	28.5	25.0	19.3	28.2
1923	41.0	38.5	37.5	36.0	40.5	30.0	34.5	33.0	21.7	29.3
1924	26.0	25.6	33.0	27.0	28.0	24.0	21.3	22.0	21.7	22.9
1925	48.0	43.5	42.0	36.0	43.9	29.5	17.5	26.0	16.6	28.8
1926	41.0	38.0	35.0	34.0	39.0	27.2	18.0	15.5	11.0	27.0
1927 [1]	32.5	31.5	30.0	30.5	36.5	29.0	29.0	33.1	30.0	28.2

[1] 1927 figures preliminary.

THOUSANDS OF ACRES OF CORN IN CORN BELT STATES AND UNITED STATES [1]

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	76,205
1892	2852	3527	6,310	896	7,075	5505	794	5572	5952	70,627
1893	.....	.....	.....	.....	.....	.....	.....	.....	.....	72,037
1894	.....	.....	.....	.....	.....	.....	.....	.....	.....	62,582
1895	2846	3702	6,821	1152	8,504	6613	1119	7807	8426	82,076
1896	3017	3813	7,026	1129	8,249	6547	1197	7962	8848	81,027
1897	2835	3660	7,167	993	7,589	6612	994	8042	9024	80,095
1898	2779	3587	6,665	954	7,285	5951	1003	7559	8303	77,722
1899	2751	3733	6,865	945	7,812	6266	1154	8013	8001	82,109
1900	2889	4032	7,139	963	8,048	6453	1200	8093	8624	83,321
1901	3077	4432	9,254	1361	9,211	6578	1421	7741	7885	94,350
1902	3200	4520	9,623	1484	9,302	6775	1577	7451	7817	94,044
1903	2976	4295	8,201	1439	8,186	6260	1530	630	6707	88,092
1904	3065	4552	9,428	1554	9,296	5783	1561	7956	6440	92,232
1905	2974	4598	9,617	1508	8,768	6014	1623	8035	6977	94,011
1906	3325	4643	9,617	1492	9,450	7075	1875	7325	6750	96,738
1907	3400	4690	9,521	1615	9,160	7775	1850	7472	7020	99,931
1908	3550	4549	9,450	1615	9,068	7542	1942	7621	7100	101,788
1909	3875	4913	10,300	1690	9,200	8100	2059	7825	7750	108,471
1910	3960	4800	10,250	2040	9,470	7500	2100	7425	8950	104,035
1911	3900	4850	10,150	2200	9,850	7400	2310	7425	8700	105,825
1912	4075	4947	10,658	2666	10,047	7622	2495	7609	7575	107,083
1913	3900	4900	10,450	2400	9,950	7375	2640	7610	7320	105,820
1914	3650	4949	10,346	2600	10,248	7200	3000	7100	5850	103,435
1915	3700	5025	10,400	2800	9,950	6500	3250	7100	5550	106,197
1916	3600	5137	10,200	2600	10,050	6775	2950	7400	6950	105,954
1917	3950	5651	11,000	3000	11,100	7200	3350	9240	9156	116,730
1918	3700	5138	9,900	2750	10,434	6693	3182	6954	6130	104,461
1919	3943	4882	8,579	2998	9,959	5962	3288	7030	4188	97,070
1920	3965	4834	9,079	3288	10,300	6646	3650	7560	5007	101,699
1921	3786	4718	8,999	3820	10,330	6096	3926	7419	4601	103,850
1922	3823	4765	8,819	3979	10,123	6150	3061	7296	5098	102,428
1923	3899	5003	8,995	4297	10,776	6562	4208	8244	5629	104,324
1924	3432	4450	8,946	4595	10,912	6300	4814	8716	6021	100,863
1925	3741	4672	9,393	4136	11,234	6741	4478	9100	6623	101,359
1926	3591	4672	9,205	4343	11,170	6471	4630	8994	5563	99,713
1927	3376	4205	8,469	4172	10,947	5953	4655	8805	5897	98,914
1928 [2]	3646	4710	9,655	4047	11,174	6489	4515	8981	6732	102,380

[1] Acreage figures for United States on page 334 are probably more accurate than these figures but are not so comparable to these state figures.
[2] 1928 figures preliminary.

PRICE PER BUSHEL OF CORN ON FARM, DECEMBER 1, FOR CORN BELT STATES AND UNITED STATES, 1891–1927

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
1891	.41	.38	.37	.39	.30	.38	.35	.26	.34	.406
1892	.42	.40	.37	.37	.32	.36	.33	.28	.31	.394
1893	.40	.36	.31	.34	.27	.30	.25	.27	.31	.365
1894	.43	.37	.39	.43	.45	.40	.46	.50	.43	.457
1895	.27	.23	.22	.20	.18	.20	.23	.18	.19	.253
1896	.21	.19	.18	.19	.14	.20	.18	.13	.18	.215
1897	.25	.21	.21	.24	.17	.24	.21	.17	.22	.263
1898	.27	.25	.25	.24	.23	.27	.23	.22	.26	.287
1899	.30	.27	.26	.24	.23	.30	.26	.23	.25	.303
1900	.34	.32	.32	.29	.27	.32	.29	.31	.32	.357
1901	.57	.55	.57	.45	.52	.67	.45	.54	.63	.605
1902	.42	.36	.36	.40	.33	.33	.41	.30	.34	.403
1903	.47	.36	.36	.38	.38	.34	.35	.28	.36	.425
1904	.46	.41	.39	.36	.33	.44	.36	.33	.41	.441
1905	.43	.38	.38	.33	.34	.37	.31	.32	.33	.413
1906	.39	.36	.36	.34	.32	.38	.29	.29	.32	.399
1907	.52	.45	.44	.50	.43	.47	.46	.41	.44	.516
1908	.63	.60	.57	.55	.52	.57	.50	.51	.55	.606
1909	.56	.50	.52	.49	.49	.59	.50	.50	.54	.579
1910	.46	.40	.38	.45	.36	.44	.40	.36	.45	.480
1911	.58	.54	.55	.53	.53	.60	.53	.55	.63	.618
1912	.45	.42	.41	.37	.35	.46	.37	.37	.40	.487
1913	.63	.60	.63	.53	.60	.74	.56	.65	.78	.691
1914	.61	.58	.61	.52	.55	.68	.50	.53	.63	.644
1915	.56	.51	.54	.62	.51	.57	.49	.47	.51	.575
1916	.90	.84	.84	.80	.80	.90	.77	.78	.90	.889
1917	1.36	1.25	1.10	1.10	1.08	1.14	1.20	1.20	1.25	1.279
1918	1.30	1.19	1.20	1.11	1.22	1.43	1.10	1.28	1.49	1.365
1919	1.21	1.25	1.30	1.20	1.20	1.38	1.19	1.22	1.40	1.345
1920	.68	.59	.59	.51	.47	.64	.42	.41	.44	.670
1921	.41	.37	.38	.31	.30	.40	.26	.27	.31	.423
1922	.66	.56	.60	.56	.56	.68	.50	.58	.61	.657
1923	.74	.62	.65	.61	.62	.74	.52	.53	.64	.726
1924	1.04	.94	.95	.85	.93	.96	.80	.91	.87	.987
1925	.57	.55	.58	.56	.56	.69	.60	.61	.66	.674
1926	.60	.50	.56	.56	.56	.68	.58	.68	.70	.642
1927	.77	.68	.71	.64	.69	.75	.57	.62	.61	.723

Chicago Corn Prices

No. 2 mixed corn has been used throughout. From 1880 to 1916, inclusive, the average of the high and low for the month has been taken. Since January, 1917, each day of the month has been averaged. Previous to 1880, averages were taken either weekly or semi-monthly. All figures are derived either from the Howard-Bartels Red Book or the Chicago Board of Trade reports, or by averaging prices of the Howard-Bartels Chicago Daily Trade Bulletin. The three sources generally agree.

	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	10-Yr. Av.
January	.48	.29	.23	.47	.82	.90	.38	.70	.86	.55	.568
February	.41	.28	.23	.51	.89	.88	.35	.68	.82	.56	.561
March	.42	.27	.24	.50	.79	.79	.37	.74	.83	.54	.549
April	.46	.30	.26	.47	.92	.63	.42	.93	.82	.54	.575
May	.48	.33	.27	.48	1.04	.54	.48	.96	.88	.58	.604
June	.46	.23	.26	.48	1.15	.52	.51	.88	.85	.62	.596
July	.43	.23	.28	.48	1.30	.56	.56	.80	.88	.81	.633
August	.40	.23	.33	.49	1.26	.67	.56	.90	.97	.90	.671
September	.37	.21	.29	.60	1.30	.60	.54	1.00	.94	.84	.669
October	.38	.22	.34	.79	1.25	.49	.66	1.06	.87	.67	.673
November	.32	.22	.31	.88	1.35	.52	.87	.97	.76	.73	.693
December	.28	.24	.37	.93	.97	.43	.76	.84	.64	.76	.622
Yearly average	.407	.254	.284	.590	1.082	.628	.540	.872	.843	.675	.618

	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	10-Yr. Av.
January	.72	.47	.41	.31	.55	.66	.43	.44	.42	.30	.471
February	.70	.52	.40	.31	.58	.64	.41	.42	.40	.32	.470
March	.72	.54	.38	.32	.60	.66	.44	.40	.42	.33	.481
April	.82	.54	.40	.34	.63	.71	.47	.46	.40	.32	.509
May	.87	.54	.46	.39	.62	.71	.47	.53	.40	.34	.533
June	.83	.53	.49	.34	.60	.67	.45	.46	.36	.36	.509
July	.83	.51	.41	.36	.62	.70	.46	.48	.38	.36	.511
August	.74	.45	.41	.39	.67	.69	.45	.45	.39	.33	.497
September	.64	.47	.36	.40	.77	.59	.45	.44	.36	.35	.483
October	.60	.47	.33	.38	.76	.55	.44	.43	.34	.41	.471
November	.61	.46	.33	.38	.77	.52	.44	.45	.32	.42	.470
December	.50	.41	.31	.50	.78	.49	.45	.44	.31	.41	.460
Yearly average	.715	.492	.381	.368	.662	.632	.446	.450	.375	.354	.487

	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	10-Yr. Av.
January	.39	.37	.62	.60	.54	.37	.37	.36	.40	.34	.445
February	.37	.37	.58	.57	.54	.37	.37	.35	.47	.35	.434
March	.35	.40	.64	.56	.52	.39	.37	.37	.49	.34	.443
April	.34	.42	.74	.53	.50	.45	.37	.38	.52	.34	.459
May	.37	.43	.73	.55	.55	.47	.36	.38	.57	.34	.475
June	.36	.45	.72	.54	.54	.47	.35	.37	.51	.34	.465
July	.36	.48	.78	.50	.53	.47	.40	.36	.48	.36	.472
August	.38	.57	.77	.52	.53	.45	.42	.40	.45	.35	.484
September	.40	.67	.67	.50	.69	.43	.39	.42	.43	.33	.493
October	.40	.68	.65	.48	.50	.42	.35	.42	.43	.32	.465
November	.42	.61	.68	.52	.40	.43	.35	.44	.39	.46	.470
December	.39	.61	.55	.59	.37	.39	.37	.49	.35	.32	.443
Yearly average	.378	.505	.678	.539	.518	.426	.373	.395	.465	.349	.463

CHICAGO CORN PRICES—*Continued*

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	10-Yr. Av.
January	.29	.49	.38	.42	.35	.43	.27	.23	.27	.37	.350
February	.28	.52	.40	.42	.35	.41	.28	.23	.29	.35	.353
March	.29	.62	.39	.41	.36	.44	.29	.24	.29	.35	.368
April	.31	.71	.41	.41	.38	.47	.30	.24	.32	.35	.390
May	.34	.62	.70	.42	.38	.52	.29	.24	.35	.33	.419
June	.34	.58	.51	.40	.40	.50	.27	.24	.32	.34	.390
July	.40	.62	.50	.39	.44	.45	.26	.26	.34	.33	.399
August	.48	.63	.52	.38	.53	.40	.23	.30	.32	.32	.411
September	.48	.58	.46	.40	.53	.34	.21	.30	.30	.33	.393
October	.51	.55	.42	.39	.51	.30	.24	.27	.31	.32	.382
November	.51	.64	.42	.37	.50	.28	.24	.27	.33	.32	.388
December	.50	.49	.41	.35	.46	.26	.23	.26	.36	.31	.363
Yearly average	.394	.588	.460	.397	.433	.400	.259	.257	.317	.335	.384

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	10-Yr. Av.
January	.31	.37	.61	.46	.45	.43	.42	.42	.59	.60	.466
February	.33	.39	.59	.44	.50	.44	.41	.44	.58	.63	.475
March	.36	.42	.59	.44	.53	.47	.42	.44	.62	.66	.495
April	.40	.45	.61	.44	.51	.48	.46	.48	.67	.70	.520
May	.38	.51	.62	.45	.49	.56	.49	.53	.75	.74	.552
June	.40	.43	.66	.50	.49	.54	.52	.53	.71	.74	.552
July	.42	.51	.72	.51	.49	.56	.49	.54	.74	.71	.569
August	.39	.57	.57	.52	.54	.55	.51	.58	.79	.68	.570
September	.41	.57	.60	.49	.53	.53	.50	.62	.80	.66	.571
October	.39	.56	.58	.45	.54	.52	.49	.61	.73	.61	.548
November	.42	.61	.55	.43	.54	.49	.46	.58	.64	.63	.535
December	.38	.65	.51	.42	.46	.46	.46	.60	.60	.64	.518
Yearly average	.383	.504	.601	.463	.506	.503	.469	.531	.685	.667	.531

	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	10-Yr. Av.
January	.65	.47	.67	.49	.63	.73	.76	.99	1.81	1.40	.860
February	.65	.47	.65	.50	.62	.73	.76	1.01	1.75	1.31	.845
March	.63	.47	.70	.52	.67	.73	.74	1.12	1.72	1.51	.881
April	.59	.50	.78	.56	.67	.76	.77	1.45	1.66	1.63	.937
May	.60	.54	.79	.58	.70	.77	.74	1.64	1.62	1.77	.975
June	.59	.56	.74	.61	.71	.74	.74	1.71	1.59	1.77	.976
July	.63	.63	.72	.64	.72	.79	.81	2.00	1.65	1.94	1.043
August	.63	.64	.78	.73	.80	.79	.85	1.97	1.71	1.95	1.085
September	.55	.67	.74	.75	.78	.72	.87	2.10	1.59	1.53	1.030
October	.50	.72	.64	.70	.74	.63	1.00	1.99	1.38	1.39	.969
November	.50	.73	.54	.73	.70	.65	1.02	2.10	1.37	1.51	.985
December	.48	.70	.51	.70	.65	.72	.92	1.73	1.45	1.47	.933
Yearly average	.584	.592	.689	.626	.699	.730	.832	1.650	1.608	1.632	.964

CHICAGO CORN PRICES—*Continued*

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	10-Yr. Av.
January	1.50	.68	.50	.71	.77	1.28	.80	.77	.89		
February	1.46	.66	.56	.74	.80	1.25	.77	.76	.94		
March	1.59	.65	.58	.74	.79	1.17	.74	.73	.99		
April	1.71	.58	.59	.80	.79	1.05	.73	.74	1.04		
May	1.98	.61	.62	.81	.78	1.13	.72	.86	1.06		
June	1.86	.62	.61	.83	.86	1.11	.72	1.00	1.04		
July	1.56	.62	.64	.86	1.07	1.06	.80	1.02	1.08		
August	1.56	.57	.62	.88	1.17	1.04	.80	1.10	.98		
September	1.34	.55	.64	.89	1.16	.92	.79	.99			
October	.90	.47	.70	1.03	1.10	.82	.78	.87			
November	.78	.48	.72	.88	1.13	.83	.71	.86			
December	.72	.49	.74	.78	1.24	.80	.78	.88			
Yearly average	1.41	.582	.626	.830	.978						

Chicago Heavy Hog Prices

From 1896 to date, heavy hog prices, as compiled by Chas. A. S. McCracken for the Chicago Drovers' Journal Yearbook, have been used. From 1881 to 1895, inclusive, the average of the range of Chicago hog prices, as compiled by the Cincinnati Price Current, has been used. Properly speaking, these prices refer more nearly to average hogs than to heavy hogs. Previous to 1881, prices have been compiled from the Chicago Board of Trade reports, the grade known as heavy packers and shippers being used so far as possible.

	1860	1861	1862	1863	1864	1865	1866	1867	8668	1869	10-Yr. Av.
January	4.85	5.05	2.35	3.60	5.90	11.15	9.30	6.10	6.60	10.15	6.51
February	5.25	5.00	2.50	4.05	6.35	11.30	9.45	6.50	7.75	10.35	6.85
March	5.05	4.75	3.00	4.15	6.55	11.15	9.40	6.60	8.65	9.85	6.92
April	4.90	4.55	2.90	4.25	6.95	9.50	8.55	6.80	8.55	9.75	6.67
May	4.80	3.85	2.50	3.75	6.45	7.50	8.70	6.25	8.25	8.75	6.08
June	4.80	3.10	2.40	4.15	7.25	7.80	8.95	5.90	7.65	8.75	6.08
July	5.20	2.70	2.55	4.25	8.55	9.25	9.40	6.05	8.35	8.95	6.53
August	5.35	2.75	2.60	3.80	8.90	10.85	9.85	6.35	9.15	9.20	6.88
September	5.30	2.80	2.90	4.20	9.50	11.70	9.30	6.15	8.70	9.25	6.98
October	5.30	2.80	2.90	4.10	8.65	12.20	8.65	5.85	7.50	9.30	6.73
November	5.30	2.65	3.45	4.50	9.75	11.15	6.95	5.75	7.00	9.10	6.56
December	4.60	2.45	3.80	5.05	10.05	9.05	5.85	6.60	8.35	9.80	6.56
Yearly average	5.06	3.54	2.83	4.16	7.91	10.23	8.69	6.24	8.04	9.44	6.61

	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	10-Yr. Av.
January	9.05	6.60	4.35	3.85	5.20	6.60	7.15	6.45	4.05	2.90	5.62
February	9.00	7.30	4.45	4.20	5.35	6.95	7.95	6.15	3.90	3.70	5.90
March	8.55	6.75	4.45	4.95	5.30	7.50	8.55	5.50	3.70	3.95	5.92
April	8.80	5.60	4.25	5.40	5.50	8.25	8.05	5.55	3.55	3.70	5.87
May	8.75	4.55	4.05	4.90	5.50	7.90	7.15	5.30	3.30	3.50	5.49
June	8.60	3.80	3.90	4.45	5.55	7.00	6.05	4.85	3.50	3.75	5.15
July	9.00	4.40	4.05	4.55	6.05	7.05	7.00	4.95	4.10	3.60	5.48
August	9.50	4.40	4.65	4.60	6.90	7.75	6.15	5.05	4.25	3.40	5.67
September	9.30	4.45	4.90	4.50	7.25	8.00	6.00	5.30	3.95	3.45	5.71
October	7.90	4.30	4.60	4.30	6.00	7.95	5.90	5.35	3.45	3.60	5.34
November	6.85	4.00	4.25	3.85	6.50	7.30	5.75	4.70	2.95	3.85	5.00
December	6.15	4.15	3.75	4.70	6.85	6.95	5.95	4.25	2.70	4.55	5.00
Yearly average	8.46	5.03	4.31	4.53	6.00	7.44	6.81	5.29	3.62	3.67	5.51

	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	10-Yr. Av.
January	4.60	5.15	6.60	6.35	5.85	4.60	3.85	4.45	5.40	5.00	5.19
February	4.45	5.90	6.80	6.90	6.70	4.60	4.05	5.20	5.35	4.70	5.47
March	4.45	5.90	6.80	7.25	6.50	4.55	4.15	5.30	5.45	4.75	5.51
April	4.50	5.95	7.10	7.50	5.95	4.55	4.00	5.00	5.50	4.75	5.48
May	4.30	6.05	7.70	7.30	5.55	4.05	4.00	4.60	5.55	4.50	5.36
June	4.30	5.90	7.90	6.50	5.20	4.00	4.15	4.55	5.55	4.35	5.24
July	4.55	6.40	8.20	5.65	5.25	4.55	4.60	5.30	6.10	4.40	5.50
August	4.95	6.50	8.45	5.50	5.70	4.55	4.45	4.75	6.20	4.15	5.52
September	5.25	6.75	8.40	5.20	5.20	4.10	4.35	5.00	6.20	4.20	5.47
October	4.85	6.60	7.65	4.70	4.70	3.80	4.10	4.50	6.05	4.25	5.12
November	4.75	6.20	6.75	4.75	4.45	3.50	3.75	4.85	5.95	3.85	4.88
December	4.75	6.15	6.20	5.20	4.20	3.65	4.25	5.20	5.20	3.60	4.84
Yearly average	4.64	6.13	7.38	6.07	5.44	4.21	4.14	4.89	5.71	4.38	5.30

CHICAGO HEAVY HOG PRICES—*Continued*

	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	10-Yr. Av.
January	3.70	3.55	4.25	7.45	5.30	4.25	3.95	3.35	3.65	3.75	4.32
February	3.95	3.50	4.60	7.95	5.10	4.15	4.10	3.35	4.00	3.80	4.45
March	4.10	4.20	4.55	7.55	4.75	4.60	3.90	3.85	3.90	3.80	4.52
April	4.25	4.80	4.50	7.05	5.00	4.90	3.55	4.05	3.90	3.85	4.59
May	4.05	4.65	4.55	7.40	4.90	4.55	3.30	3.75	4.35	3.90	4.54
June	3.75	4.50	5.00	6.65	4.75	4.65	3.15	3.40	4.10	3.80	4.38
July	3.75	5.10	5.65	5.60	5.30	5.10	3.05	3.50	3.95	4.25	4.53
August	3.80	5.10	5.40	5.05	5.35	4.65	3.05	3.90	3.90	4.55	4.48
September	4.35	4.90	5.15	6.00	5.85	4.10	2.90	4.00	3.85	4.40	4.55
October	4.05	4.50	5.35	6.40	5.15	3.85	3.25	3.75	3.70	4.30	4.43
November	3.80	3.85	5.50	5.70	4.35	3.55	3.25	3.40	3.45	3.90	4.08
December	3.40	3.65	6.15	5.65	4.35	3.50	3.25	3.35	3.40	4.05	4.08
Yearly average	3.92	4.36	5.06	6.54	5.02	4.33	3.39	3.64	3.85	4.03	4.41

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	10-Yr. Av.
January	4.55	5.25	6.40	6.60	4.95	4.70	5.40	6.60	4.45	6.20	5.51
February	4.90	5.40	6.30	7.00	5.25	4.90	6.00	7.05	4.50	6.45	5.78
March	5.00	5.90	6.50	7.45	5.50	5.20	6.30	6.65	5.05	6.80	6.04
April	5.55	5.85	7.10	7.30	5.15	5.45	6.50	6.60	5.85	7.30	6.27
May	5.30	5 80	7.00	6.60	4.75	5.40	6.45	6.35	5.50	7.40	6.06
June	5.20	6 00	7.50	6.05	5.05	5.30	6.55	6.05	5.80	7.80	6.13
July	5 25	5 90	7.80	5.45	5.35	5.60	6.60	5.90	6.55	7.90	6.23
August	5.20	5.95	7.25	5.30	5.25	5.90	6.15	5.90	6.60	7.60	6.11
September	5 25	6.65	7.55	5.75	5.70	5.40	6.15	5.80	6.90	8.10	6.33
October	4.80	6.10	7.00	5.40	5.35	5.10	6.40	6.05	6.05	7.85	6.01
November	4 80	5.70	6.35	4.60	4.80	4.80	6.20	4.90	5.90	8.10	5.62
December	4.75	6.20	6.35	4.50	4.50	4.90	6.25	4.65	5.75	8.45	5.63
Yearly average	5.05	5 89	6.93	6.00	5.14	5.23	6.25	6.04	5.74	7.50	5.97

	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	10-Yr. Av.
January	8.70	7.85	6.30	7.40	8.35	6.80	7.30	11.00	16.40	17.60	9.77
February	9.20	7.25	6.25	8.05	8.55	6.70	8.30	12.50	16.70	17.65	10.12
March	10.65	6.70	7.10	8.75	8.60	6.65	9.60	14.90	17.00	19.00	10.91
April	10.00	6.15	7.85	8.80	8.50	7.05	9.70	15.80	17.40	20.30	11.16
May	9.50	5.85	7.70	8.40	8.30	7.40	9.85	16.00	17.45	20.60	11.11
June	9.35	6.15	7.50	8.50	8.15	7.35	9.75	15.65	16.50	20.30	10.92
July	8 60	6.65	7.60	8.95	8.60	6.95	9.75	15.20	17.70	21.65	11.17
August	8.25	7.15	8.05	8.10	8.75	6.70	10.20	17.00	18.90	19.75	11.29
September	8.70	6.75	8.30	8.10	8.60	7.20	10.55	18.30	19.55	17.25	11.33
October	8.45	6.50	8.65	8.15	7.55	7.75	9.85	17.25	17.55	14.25	10.60
November	7.75	6.35	7.75	7.80	7.50	6.85	9.85	17.60	17.70	14.10	10.31
December	7.65	6.25	7.45	7.70	7.10	6.60	10.00	16.95	17.55	13.50	10.08
Yearly average	8.89	6.64	7.54	8.23	8.22	7.00	9.56	15.68	17.53	18.00	10.73

CHICAGO HEAVY HOG PRICES—*Continued*

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	10-Yr. Av.
January	14.90	9.25	7.80	8.20	7.15	10.60	11.70	11.75			
February	14.30	9.10	9.60	7.85	7.15	11.20	11.95	11.65			
March	14.65	9.60	10.20	8.10	7.40	13.70	11.60	11.00			
April	14.40	8.25	10.15	7.90	7.45	12.65	11.75	10.50			
May	14.00	8.20	10.25	7.40	7.40	11.95	13.00	9.25			
June	14.35	8.10	10.10	6.75	7.10	12.40	13.50	8.65			
July	14.50	9.50	9.40	6.85	7.55	13.05	12.20	8.70			
August	14.45	9.15	8.15	7.30	8.90	12.40	11.00	8.60			
September	15.55	7.40	8.50	8.00	9.25	12.05	11.40	10.10			
October	13.70	7.40	8.60	7.35	10.20	11.00	12.00	10.20			
November	12.00	7.50	7.90	7.15	9.40	11.10	11.70	9.15			
December	9.40	6.75	8.00	7.05	9.80	10.65	11.50	8.45			
Yearly average	13.85	8.35	9.06	7.45	8.25	11.70	11.95	9.90			

CHICAGO CORN-HOG RATIOS BY DECADES

	1870–1879	1880–1889	1890–1899	1900–1909	1910–1919						50-Yr. Av.
January	11.9	11.7	12.3	11.8	11.4						11.8
February	12.6	12.6	12.6	12.2	12.0						12.4
March	12.3	12.4	12.3	12.2	12.4						12.3
April	11.5	11.9	11.8	12.1	11.9						11.8
May	10.3	11.3	10.8	11.0	11.4						10.9
June	10.1	11.3	11.2	11.1	11.0						10.9
July	10.7	11.7	11.4	11.0	10.4						11.0
August	11.4	11.4	10.9	10.7	10.3						10.9
September	11.8	11.1	11.6	11.1	11.1						11.3
October	11.3	11.0	11.6	11.0	11.0						11.2
November	10.6	10.2	10.5	10.5	10.6						10.5
December	10.9	10.9	11.2	10.9	10.5						10.9

IOWA CORN PRICES

(Prices on farms or nearest shipping point, 15th of each month)

	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	10-Yr. Av.
January	.52	.36	.54	.37	.57	.62	.60	.84	1.21	1.30	.693
February	.53	.37	.56	.38	.56	.66	.62	.90	1.28	1.24	.710
March	.52	.38	.58	.40	.58	.64	.63	1.02	1.35	1.31	.741
April	.50	.40	.65	.43	.59	.66	.66	1.26	1.38	1.47	.800
May	.49	.42	.70	.48	.61	.68	.67	1.43	1.38	1.58	.844
June	.52	.46	.68	.51	.63	.68	.68	1.51	1.36	1.64	.867
July	.54	.52	.66	.53	.64	.70	.71	1.79	1.42	1.75	.926
August	.56	.56	.66	.60	.68	.71	.75	1.84	1.48	1.76	.960
September	.52	.56	.64	.66	.70	.68	.76	1.68	1.44	1.50	.914
October	.44	.57	.56	.63	.65	.62	.77	1.53	1.26	1.22	.825
November	.38	.55	.42	.60	.58	.55	.79	1.22	1.18	1.16	.743
December	.36	.52	.36	.59	.56	.54	.80	1.14	1.29	1.22	.738
Yearly average	.490	.472	.584	.515	.612	.645	.703	1.34	1.36	1.43	.813

Iowa Corn Prices—*Continued*

(Prices on farms or nearest shipping point, 15th of each month)

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	10-Yr. Av.
January	1.26	.48	.34	.58	.63	1.08	.60	.58	.72		
February	1.28	.46	.41	.60	.66	1.10	.57	.59	.76		
March	1.34	.46	.46	.62	.66	1.03	.54	.57	.81		
April	1.47	.42	.46	.66	.67	.91	.53	.58	.85		
May	1.61	.42	.48	.70	.66	.98	.56	.69	.98		
June	1.68	.44	.50	.72	.68	1.03	.57	.85			
July	1.51	.45	.50	.74	.94	.99	.62	.88			
August	1.36	.42	.50	.74	1.02	.98	.73	.95			
September	1.15	.38	.50	.76	1.05	.88	.69	.90			
October	.80	.32	.52	.76	1.01	.70	.67	.83			
November	.56	.28	.54	.70	.95	.61	.58	.69			
December	.49	.31	.58	.60	1.03	.57	.57	.74			
Yearly average	1.21	.403	.482	.681	.830						

Illinois Corn Prices

(Prices on farms or nearest shipping point, 15th of each month)

	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	10-Yr. Av.
January	.57	.40	.57	.43	.62	.67	.64	.88	1.20	1.27	.725
February	.59	.40	.60	.46	.60	.69	.65	.95	1.30	1.22	.746
March	.58	.40	.62	.46	.62	.68	.65	1.04	1.33	1.32	.770
April	.56	.42	.70	.49	.64	.72	.67	1.28	1.32	1.49	.829
May	.54	.45	.76	.53	.66	.74	.69	1.50	1.29	1.62	.878
June	.56	.49	.75	.56	.68	.72	.70	1.57	1.28	1.70	.901
July	.58	.54	.72	.60	.70	.74	.73	1.83	1.36	1.82	.962
August	.58	.59	.72	.67	.75	.74	.78	1.89	1.43	1.86	1.001
September	.54	.60	.69	.72	.76	.70	.80	1.76	1.43	1.62	.962
October	.47	.60	.58	.68	.70	.62	.82	1.61	1.28	1.32	.868
November	.40	.58	.46	.64	.64	.56	.84	1.26	1.19	1.27	.784
December	.38	.55	.41	.64	.62	.58	.84	1.13	1.27	1.34	.776
Yearly average	.529	.501	.623	.573	.665	.680	.734	1.39	1.31	1.49	.850

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	10-Yr. Av.
January	1.40	.58	.40	.64	.67	1.08	.62	.55	.72		
February	1.43	.54	.46	.66	.68	1.07	.63	.58	.77		
March	1.48	.54	.50	.68	.69	1.04	.58	.54	.83		
April	1.62	.52	.51	.72	.71	.99	.58	.56	.90		
May	1.76	.54	.54	.76	.72	1.03	.59	.66	1.02		
June	1.84	.54	.54	.77	.76	1.06	.61	.86			
July	1.66	.54	.56	.80	.96	1.02	.63	.90			
August	1.48	.52	.56	.80	1.04	1.00	.73	.97			
September	1.29	.46	.56	.80	1.08	.90	.70	.93			
October	.93	.40	.56	.77	1.04	.72	.69	.85			
November	.68	.36	.58	.70	.94	.64	.58	.73			
December	.60	.38	.62	.66	1.06	.60	.59	.75			
Yearly average	1.35	.493	.532	.730	.962						

Corn (American Mixed)—Average Spot Prices per Bushel of 56 Pounds at Liverpool *

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
January	.92	.82	.91	1.04	1.40	1.95	2.16	2.11	†	1.49	.81
February	.95	.82	.91	1.11	1.47	2.00	2.16	2.11	1.93	1.15	.90
March	.94	.81	.91	1.10	1.43	2.05	2.16	1.65	2.14	1.13	.85
April	.95	.82	.91	1.09	1.43	1.98	2.16	1.63	2.16	1.01	.83
May	.95	.82	.91	1.13	1.47	2.03	2.16	1.63	2.04	.95	.84
June	.95	.82	.92	1.08	1.28	2.05	2.16	1.61	2.06	.97	.84
July	.93	.82	.93	1.10	1.37	2.05	2.34	1.55	†	.98	.98
August	.99	.90	1.13	1.18	1.44	2.05	2.52	†	†	.92	.92
September	.99	.95	1.11	1.16	1.41	2.05	2.52	†	†	.85	.90
October	.99	.89	1.04	1.16	1.48	2.05	2.52	†	1.63	.71	1.00
November	.91	.90	1.00	†	1.71	2.05	2.53	†	1.58	.78	1.00
December	.86	.91	.98	1.23	1.83	2.05	2.53	†	1.38	.85	1.00

	1923	1924	1925	1926	1927
January	.99	1.06	†	1.01	1.14
February	1.00	1.15	†	1.00	1.07
March	1.00	1.13	†	.92	1.00
April	1.06	1.06	†	.97	.97
May	1.07	1.08	†	†	.99
June	1.09	1.00	†	.94	1.06
July	.95	1.12	†	1.02	1.11
August	1.16	†	†	†	1.18
September	1.16	†	†	†	†
October	†	†	1.19	†	†
November	†	†	1.16	†	
December	†	†	†	†	

* Broomhall's Corn Trade News.
†No quotations.

Corn—Spot Prices per Bushel of 56 Pounds at Buenos Aires *

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
January	†	.54	.55	.54	.56	1.07	.79	.57	.70	.88	.63
February	†	.54	.56	.61	.60	1.07	.79	.52	.71	.91	.73
March	†	.54	.56	.56	.56	.99	.74	.47	.83	.91	.79
April	.58	.56	.54	.57	.51	1.03	.59	.55	1.03	.78	.77
May	.53	.55	.59	.54	.45	1.27	.53	.55	1.13	.61	.75
June	.52	.55	.55	.50	.43	1.46	.57	.55	1.10	.63	.71
July	.51	.55	.57	.51	.45	1.43	.64	.96	.96	.65	.78
August	.52	.55	‡	.49	.51	1.27	.68	1.07	.90	.66	.78
September	.50	.62	.55	.51	.55	.87	.65	.91	.92	.65	.76
October	.51	.59	.49	.51	.70	.85	.63	.79	.83	.58	.74
November	.52	.58	.53	.54	1.03	.95	.63	.74	.77	.61	.70
December	.53	.58	.54	.52	.93	.88	.63	.71	.82	.63	.74
Average	.52	.56	.55	.53	.61	1.10	.66	.70	.89	.71	.74

CORN—SPOT PRICES PER BUSHEL OF 56 POUNDS AT BUENOS AIRES * —*Continued*

	1923	1924	1925	1926	1927						
January	.80	.78	1.12	.78	.60						
February	.82	.82	1.08	.73	.63						
March	.81	.77	.96	.66	.62						
April	.80	.67	.92	.70	.60						
May	.77	.65	1.00	.68	.60						
June	.75	.64	.92	.68	.63						
July	.73	.68	.93	.68	.70						
August	.69	.85	.96	.70	.76						
September	.74	.93	.91	.65	.76						
October	.78	1.05	.88	.60	.77						
November	.81	1.06	.84	.56	.76						
December	.79	1.07	.86	.55	.76						
Average	.77	.83									

* International Yearbook of Agricultural Statistics, 1912–1921. Review of the River Plata, 1922. Average of weekly quotations.

† No quotations.

‡ Interpolation, no quotation.

CORN—SPOT PRICES PER BUSHEL OF 56 POUNDS OF YELLOW LA PLATA AT LIVERPOOL *

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
January	†	.71	.65	.98	1.40	‡1.89	2.23	2.04	§1.49	1.28	.92
February	†	.75	.66	1.06	1.44	1.92	2.23	2.04	‖1.77	1.22	1.08
March	†	.76	.68	1.02	1.42	2.00	2.23	1.75	‖1.96	1.30	1.08
April	†	.74	.68	1.06	1.43	2.16	2.23	1.74	1.97	1.28	1.03
May	.97	.72	.74	1.11	1.47	†	2.23	1.74	1.81	1.18	1.06
June	.87	.69	.76	.97	1.33	2.17	2.23	1.72	1.67	1.09	1.01
July	.71	.67	.78	.92	1.45	2.17	2.42	1.65	1.53	1.05	1.10
August	.75	.67	.97	.90	1.54	2.17	2.61	1.65	1.43	.93	1.10
September	.78	.70	.93	.85	1.39	2.17	2.61	1.69	1.60	.83	1.09
October	.72	.66	.83	.94	1.48	2.17	2.61	1.68	1.49	.72	1.08
November	.68	.63	.78	1.06	1.69	2.17	2.61	1.65	1.15	.78	.96
December	.67	.67	.83	1.19	1.81	2.17	2.61	1.52	1.25	.88	1.00
Average	.77	.70	.77	1.00	1.49	2.11	2.40	1.74	1.59	1.04	1.04

	1923	1924	1925	1926	1927	1928					
January	.99	1.03	1.31	.97							
February	1.04	1.15	1.29	.91							
March	1.05	1.11	1.14	.89							
April	1.09	1.07	1.11	.94							
May	1.14	1.12	1.30	.89							
June	1.10	1.00	1.28	.87							
July	1.02	.94	1.27	1.00							
August	.94	1.04	1.38	.98							
September	.98	1.14	1.20	.90							
October	.97	1.24	1.03	.93							
November	.96	1.21	1.07	.97							
December	1.02	1.22	1.10								
Average	1.02	1.11									

* Statement prepared by Foreign Section, Division of Statistical and Historical Research, Bureau of Agricultural Economics.

† Not quoted.

‡ Trading in maize controlled January 5, 1917.

§ Afloat price.

‖ Nominal.

IOWA RAINFALL IN INCHES

Year	March	April	May	June	July	August	September
1890	1.57	1.80	3.56	7.76	1.98	3.41	2.97
1891	2.60	2.15	3.18	5.39	4.22	4.24	1.33
1892	2.22	4.75	8.77	5.19	5.29	2.24	1.53
1893	2.14	4.21	3.45	3.91	3.33	2.32	2.34
1894	2.03	3.07	1.87	2.67	0.63	1.58	3.57
1895	0.83	2.62	3.19	4.32	3.40	4.43	3.03
1896	1.10	5.02	6.69	3.11	6.90	3.52	4.09
1897	2.39	5.35	1.92	3.81	3.26	1.86	2.04
1898	1.94	2.56	4.67	4.72	2.98	3.44	2.69
1899	1.62	2.40	6.23	5.04	3.07	3.68	0.93
1900	2.06	2.67	3.31	3.98	6.15	4.65	4.98
1901	2.64	1.79	2.35	3.71	2.34	1.29	4.77
1902	1.45	1.71	5.39	7.16	8.67	6.58	4.35
1903	1.38	2.98	8.55	2.86	4.83	6.64	3.81
1904	2.18	3.63	3.78	3.45	4.41	3.43	2.78
1905	2.04	3.03	5.95	5.53	2.91	4.05	3.81
1906	2.34	2.42	3.54	3.92	3.04	3.95	4.16
1907	1.35	1.32	3.48	5.35	7.27	4.33	2.75
1908	1.58	2.24	8.34	5.66	3.66	4.77	1.20
1909	1.53	4.58	4.34	6.41	4.77	1.81	3.58
1910	0.17	1.48	3.41	1.99	1.86	3.88	3.59
1911	0.93	3.09	3.76	1.82	2.27	3.32	5.12
1912	2.01	2.66	3.33	2.74	3.71	3.78	3.98
1913	2.48	3.28	6.24	3.31	1.82	2.68	3.31
1914	1.69	2.52	3.31	5.57	2.27	2.19	7.88
1915	0.96	1.41	7.34	4.16	8.32	2.81	6.03
1916	1.57	2.62	4.93	3.71	1.78	2.58	3.89
1917	1.84	4.55	3.87	6.65	2.27	2.29	2.90
1918	0.63	2.32	6.87	5.29	3.17	3.61	1.87
1919	2.33	4.78	3.11	6.13	2.86	2.59	5.34
1920	3.02	4.59	3.26	3.56	4.22	3.35	3.30
1921	1.57	3.34	4.23	3.76	2.53	5.04	6.72
1922	1.97	3.06	3.53	1.82	6.31	3.06	2.03
1923	2.87	2.09	2.84	4.93	1.75	5.42	5.79
1924	2.65	1.38	1.71	8.10	3.67	5.35	3.13
1925	0.93	2.20	1.16	6.64	2.66	3.47	5.04
1926	1.06	0.91	2.76	4.52	3.72	3.80	9.76
1927	1.92	4.84	4.69	2.42	1.96	2.36	4.56
1928	1.44	2.24	2.47	5.38	4.43	6.42	

IOWA TEMPERATURE IN DEGREES FAHRENHEIT

Year	March	April	May	June	July	August	September
1890	.....	.....	57.7	72.7	75.6	68.4	59.3
1891	.....	.....	58.3	69.1	68.5	69.1	67.3
1892	.....	.....	54.0	69.2	73.0	71.4	64.7
1893	31.8	45.5	56.6	71.2	75.0	69.4	64.7
1894	41.0	51.7	61.1	73.2	76.4	74.6	65.1
1895	34.4	54.2	61.4	69.7	72.1	71.9	66.8
1896	30.9	54.5	65.5	69.1	73.6	71.7	58.5
1897	32.0	47.9	58.5	69.1	75.6	68.9	70.9
1898	37.5	48.1	59.6	71.4	73.4	71.2	65.3
1899	23.0	48.9	60.2	70.7	73.1	74.4	62.5
1900	30.7	52.2	63.2	69.7	73.4	77.4	64.4
1901	34.2	44.9	60.7	72.3	82.4	73.8	63.3
1902	39.1	48.2	63.8	65.2	73.1	69.1	59.1
1903	38.8	49.8	61.6	64.6	72.9	69.1	60.8
1904	34.8	44.1	59.6	67.1	70.6	69.1	64.0
1905	41.5	47.5	58.3	69.9	70.6	74.3	65.8
1906	27.1	52.5	60.8	67.9	70.9	74.1	67.2
1907	40.6	41.5	53.5	66.5	73.7	71.1	62.8
1908	37.9	50.5	59.4	67.1	73.0	70.0	67.9
1909	32.5	43.8	57.9	69.1	72.3	76.1	62.4
1910	48.9	52.5	55.4	69.5	74.5	71.9	63.2
1911	39.4	46.7	64.9	75.7	75.5	71.7	65.8
1912	24.9	49.9	62.7	66.2	74.6	71.0	62.1
1913	31.9	50.2	59.4	71.5	76.1	76.6	64.5
1914	34.7	48.6	62.2	72.2	76.6	73.7	64.5
1915	29.3	57.2	56.1	65.1	69.5	65.9	63.7
1916	35.2	47.1	59.9	64.5	79.7	74.0	62.5
1917	34.6	45.5	55.1	66.0	74.3	69.4	62.6
1918	42.9	44.8	64.9	70.8	73.1	76.0	58.6
1919	37.5	48.4	58.2	71.9	77.4	71.5	67.5
1920	38.0	42.4	59.4	70.7	72.3	69.3	66.5
1921	42.8	52.4	63.3	74.7	77.9	72.1	67.3
1922	38.3	49.9	63.4	72.2	71.5	73.8	67.1
1923	29.4	48.4	59.6	70.9	76.5	70.6	64.2
1924	31.9	50.5	54.1	66.8	70.2	71.7	59.1
1925	40.1	56.5	57.8	70.4	74.1	72.4	69.0
1926	32.1	46.1	64.5	66.2	74.8	73.5	63.0
1927	39.6	49.2	58.4	66.4	72.9	67.9	67.4
1928	38.9	44.3	62.6	64.5	73.9	72.7	

ILLINOIS RAINFALL IN INCHES

Year	March	April	May	June	July	August	September
1890	3.92	3.64	3.97	5.31	1.73	2.85	2.74
1891	3.15	3.18	2.25	4.19	2.01	4.74	1.07
1892	2.14	6.43	8.14	5.86	3.86	2.37	1.97
1893	3.12	7.69	4.34	3.45	1.92	0.98	3.07
1894	2.82	2.75	3.28	2.26	1.46	1.77	4.94
1895	1.62	2.08	2.38	2.77	5.36	2.85	2.88
1896	1.84	2.96	5.78	3.88	6.35	2.80	5.46
1897	5.96	4.26	1.93	4.57	3.45	1.12	1.02
1898	7.29	3.26	5.78	4.34	2.93	4.41	4.86
1899	2.99	1.54	6.06	2.75	3.74	2.57	2.04
1900	1.99	1.54	4.22	4.41	4.19	3.87	3.55
1901	3.46	1.65	1.89	3.31	2.39	1.84	1.96
1902	3.39	2.39	4.18	8.01	4.79	4.37	4.07
1903	3.02	4.29	3.19	2.86	3.72	4.46	3.79
1904	6.23	3.71	3.41	3.09	4.62	4.07	5.05
1905	2.27	3.64	4.41	3.39	4.86	3.45	3.08
1906	3.84	2.07	2.70	3.25	2.36	3.98	5.00
1907	3.08	2.75	4.02	4.46	5.72	5.47	2.64
1908	3.11	4.40	7.76	2.86	3.40	2.45	1.29
1909	2.34	6.24	4.01	4.15	4.52	2.22	3.69
1910	0.26	3.44	4.96	2.29	4.11	2.70	4.54
1911	1.72	5.06	1.92	2.77	2.34	4.19	8.74
1912	3.28	4.90	3.84	3.27	4.26	4.04	2.88
1913	5.53	2.83	3.09	2.49	2.23	2.37	2.94
1914	2.22	2.22	2.30	2.61	1.49	3.43	3.83
1915	0.84	1.35	6.99	4.79	6.69	6.09	4.22
1916	1.96	1.64	4.69	5.56	1.25	4.15	2.92
1917	2.85	4.76	4.22	5.48	2.86	2.66	2.61
1918	0.96	5.39	5.21	3.49	2.38	3.82	3.77
1919	3.44	2.50	5.22	4.61	1.93	2.87	3.57
1920	5.01	4.42	4.99	2.15	2.47	2.91	2.70
1921	5.13	4.81	2.09	3.75	1.84	5.12	6.62
1922	6.32	5.05	3.59	1.49	3.69	1.70	1.94
1923	4.34	2.39	4.33	3.50	2.07	4.89	3.98
1924	2.65	2.18	3.53	6.82	3.33	5.14	3.13
1925	2.25	2.66	1.38	5.04	2.96	2.54	4.97
1926	2.51	3.12	2.24	4.15	3.54	4.74	9.42
1927	4.60	6.98	6.96	3.90	3.26	3.16	5.15
1928	1.67						

ILLINOIS TEMPERATURE IN DEGREES FAHRENHEIT

Year	March	April	May	June	July	August	September
1890	33.1	53.1	59.3	75.4	75.9	70.5	61.9
1891	34.0	53.8	59.2	72.0	71.0	71.6	69.4
1892	35.9	49.4	58.6	71.7	74.3	73.4	65.1
1893	38.0	50.6	59.3	72.3	77.8	72.7	67.9
1894	45.8	53.8	61.5	75.0	76.3	74.7	67.5
1895	39.0	54.8	63.8	74.8	74.1	75.0	70.7
1896	35.6	59.0	69.5	71.4	75.2	73.3	62.9
1897	39.5	50.4	59.3	71.0	77.0	71.7	71.3
1898	43.4	49.6	62.2	73.3	75.5	73.8	69.3
1899	34.3	53.8	64.0	73.3	75.3	76.3	65.4
1900	35.2	53.5	64.8	71.1	75.5	79.8	69.4
1901	39.5	50.0	61.6	74.9	82.2	74.8	66.7
1902	43.1	50.8	67.2	69.6	76.2	71.9	63.0
1903	45.5	52.8	65.2	66.3	75.9	72.7	64.8
1904	40.0	46.8	62.2	69.7	73.2	70.8	67.3
1905	45.4	51.9	63.1	72.6	73.1	75.0	68.3
1906	31.1	55.3	63.8	70.5	73.8	76.3	70.7
1907	47.7	44.1	56.7	68.4	75.7	72.9	65.7
1908	44.6	52.5	63.3	70.5	75.4	74.0	70.4
1909	39.4	50.3	60.3	71.9	73.4	77.2	65.0
1910	51.9	53.4	58.0	70.1	76.3	73.3	66.9
1911	41.9	50.0	68.2	75.5	76.2	73.2	69.6
1912	30.9	53.4	64.8	68.4	75.7	72.6	67.9
1913	37.4	52.4	62.9	73.9	78.3	78.1	67.1
1914	38.3	52.7	65.3	75.5	79.0	76.0	66.8
1915	35.5	58.9	59.8	68.5	72.8	67.7	68.5
1916	38.6	50.9	63.6	67.2	80.8	77.0	65.1
1917	42.0	49.8	56.6	68.5	75.1	71.8	65.0
1918	47.4	47.9	67.1	72.1	73.8	78.8	60.0
1919	42.7	53.4	59.8	75.0	78.7	73.6	69.9
1920	42.3	47.3	61.4	72.1	74.5	72.6	69.7
1921	50.0	55.6	65.5	76.6	80.7	74.2	71.6
1922	42.9	53.9	66.5	73.9	75.0	75.1	70.3
1923	37.2	51.2	60.9	73.2	77.1	74.0	66.6
1924	36.6	54.0	56.9	70.0	71.9	74.1	61.9
1925	44.1	58.6	59.3	74.7	75.8	74.6	73.2
1926	34.8	46.4	64.8	68.3	76.5	75.7	67.7
1927	44.4	53.2	61.2	68.0	74.5	69.1	71.0
1928	42.8						

NEBRASKA RAINFALL IN INCHES

Year	March	April	May	June	July	August	September
1890	1.84	1.97	2.34	3.63	2.10	2.24	0.99
1891	1.86	3.14	2.90	7.07	5.48	2.92	1.28
1892	1.62	4.00	5.63	2.18	2.57	3.20	0.48
1893	1.32	1.25	2.66	3.10	2.62	2.33	1.02
1894	0.90	1.97	0.91	3.19	1.43	0.74	1.21
1895	0.72	2.28	2.40	4.67	1.73	3.04	1.39
1896	1.45	4.82	4.03	4.04	3.87	1.81	2.37
1897	1.49	3.82	1.66	3.60	2.57	2.60	1.26
1898	0.61	2.14	4.86	3.54	2.12	2.24	2.30
1899	0.92	0.99	3.71	3.83	2.87	3.26	0.46
1900	0.62	4.68	2.32	2.50	4.54	3.46	2.66
1901	1.90	2.32	1.86	4.54	1.59	2.25	4.55
1902	1.18	1.07	4.14	5.12	5.93	3.25	3.54
1903	0.72	1.80	7.27	2.21	4.94	5.05	1.52
1904	0.53	2.00	3.68	4.71	4.44	2.80	1.98
1905	1.31	3.70	5.73	5.04	4.67	2.79	3.79
1906	1.87	4.35	2.76	2.70	2.70	3.66	3.33
1907	0.44	0.95	2.88	4.03	4.57	2.34	2.50
1908	0.46	1.26	4.98	6.74	4.28	3.60	0.76
1909	0.98	1.06	3.23	4.26	3.90	2.02	2.96
1910	0.31	0.63	2.80	2.65	1.81	4.27	2.24
1911	0.41	2.55	2.27	1.76	3.02	3.49	2.11
1912	2.77	2.18	1.80	2.31	3.26	3.22	2.69
1913	1.51	2.68	3.60	2.73	2.34	1.42	2.18
1914	1.10	2.44	2.67	4.66	1.84	2.70	2.18
1915	1.99	3.28	5.25	5.81	6.01	3.96	3.60
1916	0.45	1.52	3.51	3.38	1.78	3.51	1.31
1917	1.25	3.14	4.85	3.24	1.17	2.34	2.69
1918	0.48	2.17	3.97	1.93	3.17	2.34	1.67
1919	0.88	3.12	2.54	4.94	2.56	1.51	2.94
1920	0.89	5.03	3.55	2.95	2.73	3.77	1.20
1921	0.64	1.94	3.62	2.35	4.08	2.50	2.32
1922	1.12	2.70	2.77	2.41	4.54	1.77	0.85
1923	0.36	2.50	4.99	4.70	2.83	4.76	3.70
1924	1.69	0.72	1.90	4.27	3.75	2.15	2.24
1925	0.69	2.38	2.06	4.46	2.16	3.46	1.81
1926	0.64	0.52	2.78	2.75	2.75	3.68	3.51
1927	2.57	4.84	2.48	3.66	1.94	3.36	2.18
1928							

RAINFALL IN MISSOURI, IN INCHES

Year	March	April	May	June	July	August	September
1890	2.61	3.17	3.47	2.59	2.98	4.84	3.98
1891	3.01	3.90	4.26	6.94	3.55	5.34	0.63
1892	3.11	5.66	7.80	3.18	4.99	2.42	2.39
1893	2.86	7.84	5.89	4.61	4.91	2.20	3.92
1894	2.93	3.17	3.99	3.92	2.48	1.58	4.93
1895	2.14	1.95	4.08	5.77	6.79	4.23	2.45
1896	2.05	3.51	9.09	8.32	5.87	3.25	4.17
1897	6.07	4.55	2.56	6.18	3.22	2.39	0.74
1898	7.09	3.65	7.90	5.88	5.58	3.03	6.74
1899	2.93	3.70	6.26	3.87	4.51	3.35	2.01
1900	1.48	3.36	3.69	4.79	4.11	3.51	4.81
1901	3.74	2.85	1.47	2.13	2.02	1.88	2.31
1902	3.49	2.66	5.03	6.57	4.59	6.16	4.78
1903	3.35	3.54	7.10	3.25	3.22	5.40	4.41
1904	4.14	5.75	5.03	6.42	4.65	5.46	3.85
1905	2.99	3.19	4.87	3.09	7.45	4.69	7.67
1906	3.93	2.24	2.16	4.95	3.53	4.72	4.15
1907	2.82	3.43	5.56	5.84	4.57	3.71	1.93
1908	2.58	5.30	6.92	6.30	2.23	3.87	1.80
1909	3.07	4.35	5.34	5.21	6.41	0.55	4.62
1910	0.66	3.51	6.62	3.92	6.70	2.77	5.58
1911	1.85	4.99	1.55	1.78	3.95	4.20	7.13
1912	4.62	5.98	3.86	4.78	2.74	4.19	3.06
1913	4.36	3.33	3.05	2.57	3.13	1.06	4.63
1914	2.75	3.14	1.47	2.37	2.67	4.25	6.27
1915	1.50	2.03	7.86	6.51	6.05	7.86	5.25
1916	2.53	3.23	5.61	6.99	1.25	4.05	2.94
1917	2.91	5.97	4.33	3.78	2.96	4.45	2.78
1918	0.94	5.10	5.49	3.15	1.76	3.34	4.73
1919	2.40	3.01	5.30	5.59	2.33	4.29	3.29
1920	5.01	3.95	4.85	2.35	3.25	4.78	4.81
1921	4.69	5.37	3.69	5.71	2.32	5.27	7.03
1922	6.46	6.21	3.17	1.66	5.85	2.40	3.31
1923	4.12	3.12	4.59	5.48	3.07	3.99	4.59
1924	2.55	2.07	4.67	7.39	5.39	4.14	3.77
1925	1.95	4.11	2.14	6.10	2.71	3.45	6.46
1926	2.89	2.46	2.73	3.62	3.14	5.63	8.79
1927	5.87	8.46	6.98	5.77	4.13	5.06	3.71
1928							

INDIANA RAINFALL IN INCHES

Year	March	April	May	June	July	August	September
1890	5.61	4.34	4.81	4.67	1.92	4.30	4.27
1891	4.92	2.96	1.58	4.42	2.47	4.85	1.98
1892	2.32	6.27	7.95	5.24	3.31	2.53	2.91
1893	2.83	8.46	4.46	3.45	1.83	1.02	3.31
1894	2.97	2.94	4.61	2.62	1.43	1.80	3.20
1895	1.48	2.24	1.63	2.75	3.19	2.20	2.23
1896	3.10	1.81	4.50	4.29	7.61	5.21	5.02
1897	6.66	4.33	3.20	4.31	3.36	1.59	0.59
1898	8.11	2.06	4.49	3.81	3.02	3.36	4.06
1899	4.42	1.60	3.95	2.86	3.28	3.03	1.74
1900	2.06	1.64	4.96	5.54	4.66	3.41	2.06
1901	3.40	2.67	2.54	4.35	1.30	3.10	1.54
1902	3.12	2.05	4.32	7.45	3.38	2.24	4.76
1903	2.95	4.42	3.15	3.72	3.44	3.85	1.86
1904	8.09	3.32	3.35	3.03	2.95	2.45	3.44
1905	2.52	3.74	5.96	3.61	4.59	5.05	3.49
1906	5.16	2.13	2.31	3.44	3.18	4.67	4.07
1907	4.90	2.80	3.71	4.69	4.95	3.83	2.90
1908	4.40	4.40	6.28	2.00	2.94	1.93	0.97
1909	2.88	5.16	4.71	5.16	5.26	3.00	2.66
1910	0.22	3.43	4.07	2.02	5.77	2.14	4.53
1911	2.22	5.43	2.34	3.82	1.71	3.19	5.97
1912	4.46	4.98	4.45	2.81	5.11	5.32	3.33
1913	8.97	3.36	2.79	2.10	3.26	3.10	2.85
1914	2.58	3.16	2.64	2.38	1.85	4.73	2.34
1915	1.15	1.58	5.93	3.33	6.23	6.37	3.69
1916	2.63	2.49	4.47	6.64	2.44	3.15	2.96
1917	3.82	4.24	4.83	5.24	3.27	2.58	1.73
1918	1.88	4.16	4.97	3.31	3.14	3.26	4.19
1919	4.90	3.14	4.69	3.67	1.94	2.35	2.41
1920	3.98	5.90	3.58	3.03	3.78	3.13	2.85
1921	5.74	4.28	2.32	3.52	2.13	5.35	5.57
1922	7.06	6.08	3.62	1.93	3.49	2.11	1.85
1923	3.81	2.47	5.15	3.45	3.51	4.83	3.40
1924	3.60	3.17	4.12	6.23	1.92	3.71	3.70
1925	3.33	2.26	1.32	3.81	4.27	2.50	5.22
1926	3.05	3.75	2.88	2.93	3.30	6.16	8.17
1927	4.69	5.91	7.09	3.30	3.41	3.12	4.71

OHIO RAINFALL IN INCHES

Year	March	April	May	June	July	August	September
1890	5.29	3.45	5.52	4.50	1.99	4.66	5.56
1891	4.19	2.13	2.20	4.82	3.82	3.07	1.50
1892	2.86	3.32	6.32	5.61	3.80	2.99	2.36
1893	2.09	6.37	4.97	3.34	2.49	2.17	1.57
1894	2.16	2.31	4.00	2.65	1.56	1.67	3.31
1895	1.59	2.11	1.80	2.47	2.00	2.96	1.66
1896	3.34	2.78	2.67	4.81	8.11	3.38	5.13
1897	5.17	3.27	3.93	2.85	4.65	2.72	0.78
1898	6.23	2.38	4.10	2.86	3.98	4.50	2.56
1899	4.64	1.61	4.32	2.94	4.17	1.82	2.68
1900	2.35	1.89	2.40	3.01	4.62	3.68	1.76
1901	2.66	3.40	3.96	4.44	2.72	3.33	2.86
1902	2.76	2.21	3.09	7.48	4.69	1.67	4.55
1903	3.51	4.01	2.82	4.02	3.67	3.20	1.52
1904	5.67	3.53	3.79	2.88	4.13	2.74	1.95
1905	2.50	3.10	5.63	4.72	3.93	4.46	2.86
1906	3.97	1.89	2.17	3.42	5.14	4.77	2.92
1907	5.55	2.74	3.47	4.57	5.36	2.48	3.92
1908	5.43	3.71	4.72	2.51	4.08	2.59	0.58
1909	2.77	4.13	4.72	5.86	3.76	3.56	1.78
1910	0.26	3.49	3.80	2.66	3.17	1.58	4.05
1911	2.33	4.35	1.69	3.92	2.40	5.39	4.87
1912	4.17	4.47	3.12	3.17	5.70	4.08	3.11
1913	8.40	3.35	3.53	1.87	5.20	2.52	2.37
1914	2.41	4.01	3.11	3.14	2.19	5.08	1.41
1915	1.44	1.42	3.99	4.36	6.32	4.52	4.51
1916	4.15	2.35	4.27	4.86	1.92	3.11	2.56
1917	3.65	3.38	4.18	4.99	3.88	2.70	1.86
1918	2.49	3.23	4.49	2.68	2.61	3.64	3.75
1919	4.04	3.02	4.78	2.88	4.02	4.46	1.90
1920	2.72	5.78	2.45	4.53	4.50	4.36	2.56
1921	5.94	3.90	3.20	2.81	2.93	4.21	4.29
1922	5.15	4.52	4.69	2.98	3.70	3.26	2.81
1923	3.00	2.60	3.56	3.38	3.57	4.34	3.12
1924	3.53	2.71	4.10	6.38	2.84	2.12	4.80
1925	2.63	2.04	2.61	2.85	4.69	2.34	3.76
1926	2.28	3.17	2.51	3.11	4.29	5.92	7.28
1927	3.83	4.13	4.73	3.62	4.54	2.50	2.18
1928							

GOVERNMENT CORN CONDITION

As Reported First of Each Month During Growing Season

Year	Iowa				Illinois			
	July 1	Aug. 1	Sept. 1	Oct. 1	July 1	Aug. 1	Sept. 1	Oct. 1
1891	94	90	90	90	96	88	88	92
1892	75	79	78	79	70	73	70	71
1893	98	102	96	93	92	81	64	66
1894	100	45	40	47	99	75	78	78
1895	105	107	96	96	92	106	97	99
1896	94	103	103	102	98	106	100	102
1897	75	78	70	74	82	93	84	81
1898	100	92	82	80	83	72	80	84
1899	81	82	83	78	86	91	89	86
1900	102	105	104	100	92	96	94	91
1901	87	57	55	59	87	51	49	51
1902	90	93	91	76	91	95	94	94
1903	74	72	67	71	78	74	77	82
1904	86	87	85	86	87	89	86	86
1905	88	89	89	90	93	95	96	96
1906	96	95	95	97	90	82	88	87
1907	78	78	76	70	82	85	86	86
1908	83	83	80	80	80	77	72	72
1909	86	85	79	77	94	91	84	84
1910	84	80	82	86	84	84	86	88
1911	98	68	68	70	89	74	78	76
1912	83	89	93	91	78	79	85	86
1913	89	85	76	77	83	72	62	51
1914	100	91	81	84	88	65	64	67
1915	74	72	65	63	82	83	78	81
1916	80	84	82	83	80	75	71	72
1917	86	87	82	80	81	87	89	86
1918	97	95	83	83	91	84	74	76
1919	87	87	89	90	89	76	76	78
1920	90	94	90	93	79	75	72	78
1921	83	92	92	91	98	79	84	81
1922	91	94	94	96	84	85	82	80
1923	91	90	89	90	86	85	90	85
1924	72	74	71	67	66	70	69	69
1925	95	90	88	90	93	91	89	89
1926	84	76	79	78	75	72	79	76
1927	72	73	67	75	57	57	53	60
1928	90	95	93	.....	79	83	84	

GOVERNMENT CORN CONDITION—*Continued*

As Reported First of Each Month During the Growing Season

Year	Indiana				Ohio			
	July 1	Aug. 1	Sept. 1	Oct. 1	July 1	Aug. 1	Sept. 1	Oct. 1
1891	95	88	90	94	93	93	95	97
1892	72	74	75	77	80	81	79	80
1893	96	79	59	61	93	85	64	70
1894	96	88	80	78	92	79	70	71
1895	95	100	86	92	91	89	83	87
1896	111	105	106	106	106	105	104	106
1897	83	92	82	76	76	85	84	81
1898	94	86	95	91	90	89	92	92
1899	90	94	95	93	85	90	87	86
1900	89	98	99	98	90	98	95	95
1901	84	57	49	51	78	73	60	63
1902	90	97	99	97	87	91	93	88
1903	76	75	76	81	75	73	67	70
1904	88	91	80	80	85	86	78	77
1905	87	94	99	99	82	85	90	91
1906	86	85	95	86	86	92	99	99
1907	78	83	84	84	75	78	77	78
1908	83	75	69	67	87	85	82	82
1909	93	94	91	90	90	90	87	86
1910	84	87	85	88	85	86	72	79
1911	91	80	80	80	89	80	83	86
1912	77	80	85	89	77	81	85	90
1913	88	84	81	80	89	90	81	80
1914	88	67	69	74	87	80	81	85
1915	85	86	85	87	85	86	86	88
1916	80	82	79	78	79	74	68	68
1917	80	84	82	82	85	87	83	82
1918	81	83	77	78	86	79	72	76
1919	88	76	77	82	89	86	90	94
1920	84	86	88	93	86	88	90	92
1921	93	68	80	80	87	74	84	88
1922	82	85	83	83	82	82	79	83
1923	85	88	92	86	87	92	95	87
1924	61	59	55	56	67	59	53	54
1925	92	95	93	94	90	96	101	101
1926	72	72	83	81	70	75	84	84
1927	56	58	56	62	63	65	62	68
1928	74	81	79	.....	77	83	79	

GOVERNMENT CORN CONDITION—*Continued*

As Reported First of Each Month During Growing Season

Year	Missouri				Kansas			
	July 1	Aug. 1	Sept. 1	Oct. 1	July 1	Aug. 1	Sept. 1	Oct. 1
1891	88	87	88	86	82	88	82	83
1892	75	83	82	82	81	81	70	70
1893	92	95	92	89	93	82	73	64
1894	101	82	70	70	96	49	45	45
1895	109	115	111	111	104	90	86	80
1896	81	85	85	85	102	109	89	81
1897	92	87	74	70	90	70	61	58
1898	78	86	89	89	83	69	60	58
1899	85	88	85	81	92	106	97	93
1900	101	99	84	84	93	71	55	52
1901	70	29	29	31	74	19	19	21
1902	102	100	102	104	99	103	91	87
1903	74	71	76	80	73	67	92	78
1904	78	74	74	76	75	70	68	68
1905	95	98	98	94	95	95	88	87
1906	86	82	87	90	85	88	86	85
1907	82	86	86	84	84	84	72	67
1908	74	74	72	71	78	76	72	69
1909	91	88	68	69	91	90	57	57
1910	82	82	83	86	83	60	59	62
1911	78	61	69	71	67	54	53	49
1912	83	81	84	84	84	73	74	72
1913	85	70	41	44	81	30	10	10
1914	82	68	57	58	88	74	53	52
1915	75	71	75	79	71	76	88	91
1916	81	60	54	56	85	48	27	28
1917	87	87	91	94	77	33	40	42
1918	91	72	46	54	83	60	23	20
1919	80	74	70	73	81	69	47	45
1920	82	84	84	87	87	85	81	84
1921	90	82	86	82	89	79	72	74
1922	82	87	77	77	83	87	60	59
1923	85	85	83	83	82	80	65	66
1924	62	70	73	73	74	77	75	75
1925	89	81	80	79	81	57	51	49
1926	80	74	76	76	73	51	31	31
1927	64	70	72	77	76	83	91	90
1928	77	80	84		80	90	83	

GOVERNMENT CORN CONDITION—*Continued*

As Reported First of Each Month During Growing Season

Year	Nebraska				Minnesota			
	July 1	Aug. 1	Sept. 1	Oct. 1	July 1	Aug. 1	Sept. 1	Oct. 1
1891	90	89	89	93	90	88	82	84
1892	84	80	76	78	77	80	82	85
1893	94	84	71	65	97	101	92	95
1894	96	33	15	14	100	73	60	59
1895	95	76	56	50	97	95	97	94
1896	103	108	103	101	95	95	93	97
1897	82	84	87	86	70	77	78	86
1898	90	85	62	57	95	102	94	86
1899	93	99	85	83	84	98	96	97
1900	93	85	73	73	80	94	99	98
1901	88	36	33	35	89	78	69	75
1902	90	101	101	86	83	88	89	62
1903	75	75	80	76	81	76	73	73
1904	86	88	87	90	79	80	80	79
1905	85	90	95	95	82	86	90	95
1906	84	84	87	90	80	85	92	95
1907	80	82	75	69	70	75	76	73
1908	84	86	82	80	70	80	76	76
1909	91	93	68	69	91	91	92	92
1910	86	65	68	72	87	82	83	83
1911	82	64	63	62	98	81	82	83
1912	80	79	80	77	78	83	82	84
1913	91	67	37	39	91	95	95	99
1914	97	82	65	67	81	89	89	90
1915	76	77	81	85	65	56	52	50
1916	84	73	74	78	61	84	86	83
1917	86	74	68	77	76	83	77	60
1918	94	86	56	57	95	97	99	83
1919	88	81	71	72	88	90	93	95
1920	85	90	93	97	89	88	82	90
1921	95	81	84	83	100	95	95	95
1922	90	93	68	64	92	83	76	77
1923	86	87	90	92	93	92	83	84
1924	74	80	72	72	72	70	61	58
1925	93	70	68	70	85	83	73	79
1926	85	55	45	45	72	75	79	76
1927	80	81	85	85	69	67	52	64
1928	86	93	62	.....	77	84	83	

QUALITY OF CORN CROP IN CORN BELT STATES AND UNITED STATES

As Reported in November by Crop Reporters to the U. S. Department of Agriculture. These Figures Refer not to Yield but to Merchantable and Feeding Quality

Year	Iowa	Ill.	Ind.	Ohio	Mo.	Kan.	Neb.	S. D.	Minn.	U. S.
1896	92	93	93	93	84	84	97	96	91	91
1897	91	88	85	83	83	78	90	90	90	86
1898	85	75	83	86	80	74	75	91	90	84
1899	88	87	92	89	92	90	87	88	95	87
1900	88	91	94	91	86	73	78	91	90	86
1901	80	71	71	79	51	51	65	79	80	74
1902	66	89	86	76	94	90	75	48	51	81
1903	75	87	86	81	83	81	75	80	74	83
1904	85	89	83	80	83	82	93	83	74	86
1905	93	95	95	88	88	88	93	94	94	90
1906	96	88	90	74	91	92	95	94	94	90
1907	78	86	82	78	88	83	84	81	70	83
1908	87	90	90	93	80	83	88	91	83	87
1909	87	89	91	89	79	75	86	92	92	84
1910	95	90	88	82	88	79	87	77	85	87
1911	88	78	83	83	73	70	80	77	85	81
1912	88	89	90	91	85	83	79	74	82	86
1913	88	77	86	86	65	47	78	88	94	82
1914	91	86	82	59	70	75	90	87	92	85
1915	48	79	81	81	87	88	69	50	35	77
1916	91	83	83	78	72	68	91	83	84	84
1917	65	71	63	73	86	69	80	78	52	75
1918	96	87	88	84	73	68	90	92	90	86
1919	96	88	89	92	82	79	92	94	97	89
1920	93	84	92	90	85	88	95	94	91	90
1921	90	78	71	83	80	87	91	91	90	84
1922	95	90	88	82	84	77	87	91	83	85
1923	80	97	78	74	81	83	88	87	79	79
1924	55	70	57	56	73	84	71	44	37	63
1925	80	76	82	89	70	76	84	85	88	85
1926	83	80	81	79	80	78	84	84	85	85
1927	87	82	88	90	83	88	90	94	88	86
1928										

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